MANUAL

of

GOTHIC CONSTRUCTION

by

G. UNGEWITTER

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Rewritten by

K. MOHRMANN

Professor at the Baltic Polytechnic School at Riga

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Translated by N. Clifford Ricker. D. A.

Emeritus Professor of Architecture

University of Illinois

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Preface to First Edition.

In the first decades of the 19 th century, the generally approved and even now extremely valuable in many respects, Manual of Rural Architecture by Gilly, Wolfram, etc., designates as the three principal requirements of every structure, utility, durability and beauty. Yet to the latter has been previously assigned a secondary place, and this has been explained as allowable so far as it did not oppose the two first qualities.

This extremely rational conception is only erroneous, so far as it permits the possibility of a conflict between beauty and its preferred sisters, and even this error is based on the general idea of esthetic beauty then prevailing. Therefore it was generally adopted, particularly being made an article of faith of the state architectural officials, and had extremely injurious consequences, because the greater number of the latter were far removed in existing circumstances from examining the causes of that conflict, and to remove them from the path as far as possible, extendind further the liberty contained in this idea, even they themselves judged ugliness as allowable. Men did not express it directly, but proceeded in this wayto the conception, and indeed to the "beautiful architecture," to which ordinary architectural practice was opposed. The former almost exclusively belonged to the splendid buildings erected in the great cities, the palaces, theatres and museums, but to the latter belonged the far predominant number of utility structures, rural and communal buildings, indeed even the smaller churches (Note). That such a conception, by which an entire category of works had to remain bare and plain, whereby the great multitude of men in life could only see ugly buildings, and in all manufactures the dominant influence of the architecture could only bring to view unbeautiful objects, could not be conclusive.

(Note). The design and execution of such a one would even now be generally regarded as the lowest and least artistic treatment of the required problem. Thus there exist highly esteemed street and hydraulic engineers, who carelessly state, that although architecture proper lies far from them, yet that they are qualified to make designs for a church, a school, in brief for any building occurring in their official circle of work.

We have already designated the former conception of beauty as the cause of the unsuitable ness blamed. But it was the same for the antique architecture, when it was assumed as the basis, that its forms must serve as ideal for all time, and no doubt could exist as to their baing stanard. And still one was conscious of a certain endeavor to copy these forms, and be repeated measurings and by the introduction of models of parts, men were prepared, not only to reproduce them, but even to correct them where possible, --- how could their use then lead to errors?

But the Romans could already combine Grecian columnar architecture by a certain compulsion with the arrangement of their construction, when they transferred the porticos to the wall masses of their structures, they succeeded only by the royal magnificence of their execution in combining the opposing ideas; yet they had to proceed to a transformation of the detail forms, and then the position of later men was far worse. The organism of their structures required by the possibility of use opposed the employment of Greek forms of detail in a far higher degree, than was the case for the Romans. Splendor was lacking, a transformation of those forms was attempted by the architects of the Renaissance, was then opposed to the former written law of mudules and parts, but further to the fact that the latest past offered a much less usable material, than that inherited by the 15 th and 16 th centuries. Men were thus able to add antique beauty only in a far more powerful way than was possible to the Romans, i.e., they built in the conventional way, well or badly, and added just as much beauty, as the conditions and the possibility of use of the proper building would permit.

This beauty or rather the means of producing it, is the same for every species of building; for the church, the palace and the museum, down to the druggist's shop in the smallest provincial city, are the same fronts, columnar orders, cornices, window caps and architraves, which the consecrated service had to use; the purpose there came under consideration not the least. Just as little could the material find any attention, when marble for which the forms employed were important, and whose qualities had caused their origination, was not at hand. Whether men saw themselves obliged to construct the different

parts of that beautiful architecture of stone, gypsum or of wood, that could affect little as the form remained the same.

But since the beauty for which men strove in such manner had no relation whatever to the purpose of the building, then must it oppose suitability, since the nature of the materials found no consideration, and thus the durability would be endangered. There was not alone the possibility but almost the necessity of such a conflict.

In what is said above, we have desired only to indicate the usual point of view of the building officials and architects with a tendency to the antique. That there were highly gifted artists in this and perhaps still are, which our description does not fit, to whom it has been given to breathe a new life into those dead and foreign forms, adapting them to modern requirements, should not be denied. But how few is their number, how small their influence on the great multitude of architects.

The inadequacy of Grecian-Roman architecture then also led early in the thirties to a medley the system of infringing license. With this began from the period of different style periods of the middle ages to borrow certain alterations, certain forms of details, and to combine them with the antique-like conception of the whole, and wished by the piquant appearance of such innovations, allowed themselves to extend farther the circle of their license.

But men either abandoned first the foundation of Grecian architecture, or declared the style of one or another mediaeval period suitable for further development or requiring this, and strove to seek this development in refining the detail forms according to Greek principles.

It is in the nature of the matter, that these endeavors lacking a unity of principle, proceeding entirely from the individual views of each person, must scatter in an endless multitude of separating directions, from which finally developed the idea that the present art period must be regarded as a transient condition, in which the new Messiah was to be expected. And t therein from the very first this idea was opposed to the views of those , which were based on the everlasting of the once born, whose church is founded, will permeate all conditions, and has found an artistic form, whose diversity is as eternal as themselves

It might matter little whether this artistic form is seen in the style of the 13 or of the 12 th centuries, in the Gothic, Romanesque or the Early Christian. But we might assume that if Romanesque art did not suffice for the grand cathbedral buildings of the 13 th century, it still less suited the multiform problems of the present time, but that no problem can be conceived, for whose solution the means cannot be developed from the principle of Gothic construction.

To the absolute conception of beauty of the antique tendency described above is then contrasted the beauty of Gothic architecturein this, that it is suited to every problem, that it builds for each in its inmost being, and as a necessary result represents a well understood durability and suitability. Accordingly it shapes itself in every detail as the form best adapted to its structural purpose, but for the whole as best serving the purpose of the work and bringing the conception into the clearest expression.

Thus the beauty of the cathedral differs from that of the parish church, the beauty of the ecclesiastical structure in general is other than that of the secular. And for each of the greatly varied problems of secular architecture again is a speial character suited therefor. But the unity in the endless diversity of its solutions will result from the connection of e each with the structure of the church. Then the cathedral includes within itself the entire development of forms of all other works, just as the spirit which dwells beneath its vaults permeates all interiors. This very connection with the church, this predominance of a religious character in Gothic art, men have gladly made a reproach to it, and therefore also declared it could not serve for secular purposes. But with the same right would an individual be blamed, whose religion permeates his outward behavior, or him that fulfils his religious duties might be held unfit for worldly affairs. The palace, city hall or house indeed differ from the church, but prayer is offered in all, that serve the purposed sanctioned by religion, and therefore their exterior would contradict the inmost germ of their being, if Their derivation from the form of the church were not brought into view.

It may be that the not rare horror of the ecclesiastical

character of Gothic secular buildingsis to be ascribed in part to the account of the many recent exaggerations, in which the forms of the ecclesiastical style are employed similarly, as the building officials with a taste for the antique changed t their columnar orders; its deeper cause lies in a certain opposition to everything decided and characteristic, to all treat- of form beyond the flattest elegance. The striving for this modern elegance, the entire lack of all earnest endeavor has reached its climax in the great multitude of the different structures connected with railways. (Note). These almost have the appearance as if men desired here to attain by steam power the often promised style of the future.

Note. But of what artistic treatment these would be capable, especially Eisenlohr has shown in the buildings of the Baden railway. Yet in contrast to those works is the recently sought empty elegance, that seldom or never comes to light, and apparently is generally refused to Germans.

As now so many tendencies become apparent on the whole, the drift to Gothic architecture has increased in a series of years. Finally men have become wearied by allowing themselves to use antique or contemporary conceptions, with which so many building officials are so extremely liberal. Churches and secular works rise everywhere, which by the return from the previously traveled paths give evidence of a more or less happy but always honorable endeavor.

According to what is said above, it is now the purpose of our plates to show the different constructions of Gothic art, the formation of the details for their different functions according to the peculiarities of the materials, later to explain the works od the middle ages, and to illustrate their combination in an entirety. The buildings on which we depend and from which we have taken the different figures, are almost entirely those which we know by examination. A sharp separation of the national peculiarities can less be given, since these were naturally developed in the middle ages, as men studied and utilized the results obtained by other nations, so far as they were available. When we now follow the same way in practice, we must fear the loss of the special tinge, that the Gothic style assumed in the different countries, that it once had, yet the conditions of the materials and climate still remain.

We have so arranged the sequence of the different sections as far as possible, that each one only assumes those preceding it, and also in the figures is made the transition from the simpler to the more complex forms.

The clearness of our book will perhaps conduce to the development of the parts from the whole. But we believe that first of all is easy use to be cared for in a book, which must contain the instruction necessary for the beginner.

Cassel. Dec. 22. 1858.

G. Ungewitter.

Preface to the Second Edition.

After the death of the early departed and deserving author, whom A. Reichensperger has so fully treated in his Biography:- "George Gottlieb Ungewitter and his works as architect;" the publishers believed it to be a duty for them to introduce the necessary new edition of his "Manual of Gothic Construction" by a few commendatory words to the circle of those interested in it. The need of a manual like this is sufficiently recognized, its excellence is fully guaranteed by the ability and fame of the author, and both are sufficiently justified by the need for a new edition. We are thereby relieved from any further recommendation of the work, and so that the labors and creations of the author may receive just appreciation, we restrict ourselves to his buildings in north Germany and to his activity in the literary domain. His entire thoughts and acts culminated in the endeavor to arouse in our time the feeling for mediaeval art, to cherish serve it was also the predominating purpose in this, like all his works. It will be a guide for all practising artists and architects, that will lead them with a sure hand through the apparent confusion of Gothic forms and constructions, and as such may this new edition also enjoy a favorable reception.

Leipzig. Jan. 1875.

The Publishers.

Preface to the third rewritten edition.

George Gottlob Ungewitter's Manual of Gothic Construction, like no other of his works, is called to throw light on the d depths of mediaeval architecture, and still it has shown that the number of professionals that have made real use of it are not in proportion to the worth of its contents and to the importance of the matter.

Some mostly external circumstances have combined to make the study of the work in caft somewhat difficult. The illustrations were inconveniently separated from the text on large plates, the text itself was rather dark in arrangement and subdivision, containing many platitudes inserted for the benefit of beginners in the earlier decades. Since it is not now the affair of every man to acquire his knowledge in a toilsome way, most convince themselves that collected in a manual is gold to be acquired.

This fact and the need of additions for this time required its rewriting. The programme decided on that the publishers demanded, that without passing beyond the former limits there should be extensions and additions, explanations should be abbreviated, figures should be placed in more intimate relation to the text, and that clarity should be increased in every respect.

The first requirement to retain the former range, could not be entirely obeyed. The considerable enlargement of certain sections and the addition of about 400 figures could not be offset by reductions, and so reverence toward the author must suffer thereby; but to retain this the reviser held to be a first duty.

Additions and extensions extend through the entire work. Entirely rewritten is the section on vaults and now is inserted one on abutments, and there are added tables relating to the magnitude of the thrusts of vaults and the thickness of walls and of buttresses.

The recent advance in statics --- especially graphic statics --- applied to vaults and buttresses seemed urgent, the more because the scientific investigation just in the domains of t the complex constructions here coming in consideration has been almost entirely omitted, or where these were treated, frequently with basal assumptions, they differ from the reality.

It could not be the intention of this work to conduct a far reaching theoretical treatment, for architects would be little benefited thereby. But indeed there are sufficiently treated and are established first of all basal principles, which without tedious calculations and without much mathematical science permit a correct judgment of the effect of forces, to train a again the modern architect to feel the stresses in his structures, just as the old master could in his unfortunately lost directness of invention. With these points of view the reviser hopes to have so treated the statical explanations inserted, that they will not make more difficult the unfathomable and manysided Gothic construction, but simplify it.

Yet the theorists among professionals, to whom the new seems represented with too little science, may take it into friendly consideration, that it was here first to write for the practitioner. We have little lack of theorists for theorists, but there is ever still wanting a correct connection of theory and practice; indeed for more than nine tenths of persons engaged in building, the theoretical results of the last decades have passed over without influencing them.

In the sequence of the material appeared necessary some changes. Before the introduction of mouldings and tracery, Ungewitter himself wrote in his preface, that perhaps the developgent of the parts from the whole would be required for clearness, but he took into account the instruction of the beginner. Since in the essentially changed education of the beginner came into consideration less in the earlier sense, if these two sections were removed to a later place, and yet other changes were made. These are now preceded by the still required vaults with the buttresses and supports, and after them follows the treatment of the church in plan and elevation with the addition of the different details of construction.

To increase the clarity of the work an endeavor has beey made in all directions to subdivide the materials more, and a twofold size of type separates the continuous text from the insertions and explanations; there are added on the side margins a brief statement of the contents, and the illustrations will further serve as a speaking guide.

The illustrations are but partly inserted in the text, but in much greater number are on plates of the size of the book,

bound in at proper places and not folded. In the addition of new illustrated examples, more would have been added if the exceeding the limits had not required otherwise.

An extension of the Manual to the less fully treated domain of brick construction, and to secular architecture was not possible within the former compass, yet it is designed to add these sections to the work in separate volumes.

Here the undersigned must express in the highest veneration his thanks to his old master and instructor, C. W. Hase in Hanover, for counsel and direction, and who enabled him to make this revision.

Riga. May. 1889.

K. Mohrmann.

MANUAL OF GOTHIC CONSTRUCTION.

I. Vaults.

1. Development of the Art of Vaulting from Roman to Gothic

Vaults of the Romans.

Forms of Vaults in Roman Architecture.

Roman art knew but two basal forms in this vaulting.

1. The tunnel vault in form of a half cylinder (Fig. 1).
2. The dome in form of a hemisphere (Fig. 2).

Both originated from the same generating curve, the semicircle, one by moving it sidewise, the other by its rotation.

The tunnel vault covers rectangular rooms; the dome those w with a circular plan. But the rich development of plan was not satisfied by the circle and the simple rectangle, and men required these interiors with many variations. But a freer development of plan also demands freer forms of covering, which finds its expression in variations of these two forms of vaults.

Particularly important are the forms from the tunnel vault. When in plan two interiors of different widths intersect at right angles, then the vault of the smaller extends into the larger, and there results the form of the Welsh groin vault. (Fig. 3).

If there intersect in this way two rectangular interiors of equal widths, the intersection of their vaults forms the regular shape of the cross vault (Fig. 4).

After men were led in such manner to the latter very important form, they made use of it; they continued the vault of the rectangular room with cross tunnel vaults arranged beside each other, to obtain elevated semicircular wall surfaces along the longitudinal walls, which were very desirable here for the arrangement of openings (Fig. 5). They attained a continued series of cross vaults over a long interior. (Basilica of Maxentius, gallery of palace on the Palatine).

There now remained only one step, the arrangement in both longitudinal and transverse directions, and the problem was solved of covering a wide interior uniformly vaulted on separate supports (Fig. 6). This solution is found in the Baths and the inner rooms of the Coliseum.

A similar extension was experienced by the use of the dome. If on the ground plan of the domed interior a wall is built on a chord, it cuts each dome above in the form of a semicircle.

(Since every intersection of a dome by a plane is a circular arc). Now if such walls are joined in the plan in the form of any polygon inscribed in the circle, each wall ends at top in the form of a semicircle. But the part of the dome remaining between the walls receives the character of an independent form of ceiling, made possible by covering a polygonal room, as an octagon, square, etc., that is termed a pendentive dome (Figs. 7, 12). The pendentive dome first appeared in the later time and chiefly in the eastern half of the empire.(For example, Cisterns of Constantine at Byzantium, Tomb of Galla Placidia at Ravenna).

As a further variation of the dome the half dome for cover- niches and the hip dome are to be mentioned. The latter is also termed a cloister dome and can be derived from the tunnel vault just as well as from the dome.(Examples, Temple of Minerva Medica at Rome. Fig. 8).

The before mentioned forms include about all that the Roman art of vaulting created. They are mentioned here to show in what a direct way they were derived from the forms of rooms, without the needs of construction having much to do with them. The last circumstance is explained by the Roman technics.

Method of construction of Roman vaults.

Construction of vaults in courses of cut stone or of bricks was indeed employed by the Romans, but for the covering of architectural interiors concrete was the ever increasing method. Often the execution of this was far removed from our present methods. Men constructed a centering according to the form of the vault, laid thereon a covering of thin slabs of stone fitted close together and then laid on the concrete in horizontal layers, just as done for any other masonry (Fig. 9). That this held was naturally due first to the intimate adhesion of the great masses of mortar. But once left to the latter, within fixed limits there could be given to the centering a nearly optional form, so that the shape of the vault could be named without paying attention to its architectural appearance, which resulted from the use of the semicircular form.

For covering very large rooms of great span, such a simple procedure as the preceding would not suffice, and here appeared the practical sense of the Romans in the introduction of carefully developed methods of execution. To these belong the iso-

isolated pottery vaults, but especially the cast cellular vaults. For the latter was first placed on the centering the usual large and thin bricks, then a network skeleton, whose cells w were later filled with concrete (Fig. 10).

The importance of the brick skeleton is that it permits convenient and safe construction. When at the completion of the vault it is covered by mortar, its chief function has been fulfilled; the vault then acts like any other concrete vault as a unit by the mass held by the mortar. The thickness of such a vault at the crown usually varies between 1.2 and 3 metres.

From tunnel vaults the enclosed brick framework generally f forms rectangular panels, from which may be derived a certain structural justification for the formation of coffers. On the contrary for domes the ribs usually take the form of a relieving arch lying in the surface of the vault on another arch. Prominent examples of this kind are offered by the Pantheon, Temple of Minerva Medica, the numerous remains of other buildings at Rome, Tivoli, etc. Details are given in the important work of Choisy; Art of building by the ancient Romans.

The technics of the Romans were very developed and very manifold. But in this respect, they always pursued the same aim; whether a structure was of cut stone, bricks or concrete, it was always their endeavor to make vaults and walls a single rigidly connected mass, that by the piling of great masses should form an almost indestructible work.

Vaults of Early Christian period.

The Art in the West.

Early Christian art in the west existed in the first centuries almost exclusively on their inheritance from the Romans, particularly in regard to technics. But traditions were gradually effaced more and more, there was on one hand a decadence in good execution, but on the other the impulse led to pursuing new aims. In two directions under a partial influence of t the East a certain transformation cannot be denied, men often consciously strove to reduce the masses of the walls, and they usually wandered from the old technics of concrete. Thus in t the vaults more than formerly is found a coursed arrangement of the stones in the vaults, on which was cast mortar from above. The direction of these courses is quite varied, as generally the Early Christian period shows many groping and inst-

have received heretofore.

We can not follow the constantly increasing endeavor to represent Early Christian art as absolutely the end of the antique or the last stage of the ruin of Roman art. An abrupt stagnation that men formerly say indeed did not exist, but the slow growth of a new spirit is undeniable. Even in the devastation and the impoverishment of Roman forms is felt a conscious transition to the new path. One cannot demand from those centuries a splendid advance, they afforded no place for the senile decay and worn out ancient art; but they gathered all their endeavors to one point, and this is the first basal condition for the growth of the flower of a new style. What the temple was for the Greeks, the basilica became for the middle ages and indeed to have laid the foundation for its form is the part of the E Early Christian period; the whole living structure was reserved for the active power of a youthful and fresh people.

Art in the East.

More rapidly than in western Europe was completed the development in the East. While in the West was accepted with great preference the little changed old low roofed basilica, in the Byzantine empire a stronger acceptance of the central building afforded opportunity for new forms. Two important acquisitions appeared in the art of vaulting, the dome on pendentives and the raised cross vault. Both are clearly expressed in their entire shapes. Indeed they had earlier precursors, but they appear to have first attained their independent development in the time of Justinian.

The dome on pendentives brings a very bold idea into execution, a completely formed dome erected on four piers (Fig. 11). The plan of the dome lies entirely within the square of the piers, and therefore is not directly supported at any single point, but rather must the entire load be transmitted to the piers by the pendentives and cross arches. The pendentives form parts cut from a greater spherical surface, whose diameter corresponds to the diagonal of the bay of the vault.

For covering a square room men had three solutions:- 1, the new pendentive dome; 2, the segmental dome or Bohemian vault (Fig. 12); 3, the raised cross vault (Fig. 13).

Method of construction of Byzantine vaults.

Byzantine technics differ substantially from Roman, is not

acquainted with Roman concrete, employs stones with thick mortar joints, and uses in the vaults in extended measure freehand masonry without centering. Already under the Romans the art of the East had gone its own way., much had remained from Greek art, and the technics in the provinces were in much closer relation to that transmitted from the ancient flowering of art in Persia, Assyria and Egypt. There had men learned the primitive and also primitive invention of freehand vaulting of high domed as well as of tunnel vaulted rooms.

Where they had to do without cut stone or heavy rubble, the East Romans also certainly preferred the centering, but as soon after Augustus burned bricks came into honor everywhere, the door was widely opened to freehand vaulting.

Domes were almost always vaulted in horizontal rings and were stable after completion. To prevent the bricks from slipping in the upper courses, the beds were made more horizontal there, (Fig. 11 a), unless the upper part was not simply made pointed or conical (Persia, Arabia). The pendentives are not corbelled, but are built in vaulting courses, which further is equally s statical. The generating line of the dome often varies from the circle, since gen by foresight kept the pendentives in the four angles somewhat back. The domes of S. Mark's church at Venice --- perhaps unintentionally --- show the converse variation.

Tunnel vaults were usually turned in transverse or vertical ring courses; until they were closed, the bricks must be held by cementing to the previous ring course. To make this easier and to prevent the yielding of the course at top, it was often inclined in the way shown in Figs. 12 h and 12 i, or executed in conical rings (Fig. 12 k). The tranrverse courses frequently began at a height where horizontal courses became unsuitable, yet a change in the arrangement of courses is observed according to circumstances at the time. Very rational tunnel vaults of this kind were already erected by the Egyptians under the 19 th dynasty (Lepsius, Monuments in Egypt. I, Pl. 89).

The cross vaults of the Byzantines like the tunnel vaults r received endwise transverse courses, that alternate in the groins and were set freehand (Fig. 13). Choisy first threw light on the Byzantine mode of construction (Art of Building among the Byzantines) and believes, that men did not once need centerings under the groins of cross vaults. So far we cannot fol-

follow them for static reasons -- at least in regard to large cross vaults.

The groins of cross vaults nearly always have the form of a circular arc, somewhat less than a semicircle. Each course forms a circular arc, whose middle point lies on the horizontal axis x x, whose curve is easily executed by a string fastened at p. With this form of groin and courses the crown must take the recurved form occurring in Fig. 18, which the vault actually shows, that men certainly sought also to avoid in many examples, for instance by flatter wall arches (elliptical groins likewise produced a different crown). The groins of Byzantine cross vaults project very strongly beneath, while almost disappearing above. If the rise so far increases that the groin becomes a semicircle, then with the same mode of construction it passes for itself from the cross vault into the pendentive dome.

The pendentive dome exhibits ring courses (Fig. 12 a), transverse courses like the cross vault (Fig. 12 b), oblique courses (Fig. 12 c), and also finally an alternation of the two forms (Figs 12 d and 12 c). Such a change is also frequently carried over into the spandrel of the dome.

The technics were transmitted to the Byzantines from earlier peoples, during the Roman period they were evermore adopted by them, but under their rule the architecture became less determinative. Only when Byzantium acquired its importance as an independent centre of a great Christian empire, particularly after the 6 th century, then did the mode of building pass into a more decided expression. The conditions of construction claimed a certain leadership more surely felt than before. E But that helped to smooth the way for the endeavors of the following middle ages aiming at the same point.

While the West fixed the ground type of the church, the East loosened the compulsion of the architectural form in favor of a greater domination by the construction.

At the point of contact between East and West did not fail brisk trade relations, the Byzantine rule in Ravenna and Venice, the call of Greek architects and workmen to the courts of the West, and finally later the impressions brought home by the crusaders and pilgrims, maintained a sufficient intellectual exchange.

The traditions of Rome entered the new blooming art like a continuous chain, its fall freed Byzantium, and where one of the old cords came to an end, there the master knotted one of his own strong spinning, until at last an entirely new fabric appeared beneath a new hand skilled in art. By this picture can be represented the worth of Romanesque art, whose first problems reach the climax in vaulting after Byzantine precedents in a new monumental conception, the Roman basilica formerly covered by timbers.

Introduction of the vault in the Romanesque Basilica.

Introduction of the vault in the Romanesque basilica.

To the Romanesque basilica fell the problems as stated, to give the basilica a massive covering. Besides the distinguished monumental appearance of the Byzantine works, the ever recurring destruction by fire supplied a motive sufficient to require vaulting. In all parts of the structure, where they could be easily executed, it quickly became the rule; thus it always appears over the apse, that was covered by a half dome, and likewise is always found in the crypt, that mostly retained cross vaults with the old Roman treatment.

It was also easy to cover the side aisles, and therefore they appeared alread with faults for a long time, while the principal room of the structure, the middle aisle was still to be s satisfied with a wooden ceiling. As the forms of the vaults of the side aisles occur the longitudinal tunnel with and without compartments, the transverse tunnel and the cross vaults.

So far had the vaulting been easily completed, but there remained two places in the plan of the church, whose mastery was to form the most important problem of mediaeval art. These were:-

1. The vaulting of the middle aisle.
2. The vaulting of the choir aisle.

The latter enrichment of the choir appeared after the 11 th century.

The attainment of both of these aims formed the climax of all architectural endeavors from the end of the 11 th to the beginning of the 13 th centuries. At this time the ancient art centres of Rome and Byzantium had almost entirely receded, the centre of gravity had passed to the Northwest into the youthfully fresh peoples in modern Germany, France and England. There arose a world competition for obtaining the perfect, from

which Gothic architecture finally came forth as a magnificent result and a rapid blossoming of a conscious victory.

Different attempts in vaulting the middle aisle.

a. The longitudinal tunnel vault.

As the first fruits of vaulting the middle aisle appeared t the tunnel vault nearly everywhere, and it is found from Spain and Italy to Scandinavia (Church at Ringsaker), and it became most commonly dominant in Southeast Prince --- aside from from the three chapels in Ireland. Its introduction was natural, since it was known from the Roman works and was the most naturally added to the rectangular interior, but it carried in itself its unconquerable defect. The impossibility of lighting it satisfactorily in a plan with three aisles, its cavern-like a appearance and the difficulty of stiffening it did not allow it to succeed in a development fulfilling the purpose in spite of all experiments.

The thrust was very skilfully received by high half tunnel vaults constructed over the side aisles, but the difficulty in lighting was increased thereby.

b. The dome on pendentives.

On the other hand men preferred a good side introduction of the light by larrying the middle aisle high up --- as in Burgundy, and then the thrust again made itself strongly marked. Even if they opposed this by the introduction of the pointed form of the tunnel and successfully by buttresses, there yet remained the oppressive effect of the tunnel in the interior. They finally sought to lessen this by inserting dividing and strengthening cross arches, --- but the tunnel vault never led to real satisfaction.

Therefore men pursued other difficult solutions. Among them especially appeared the placing of fully developed pendentive domes beside each other as employed in Southwest France. The transfer of the dome there is also explained by the animated trade relations of those provinces, especially the cities of Limoges and Perigueux, with Venice, Byzantine at that time. Recently the influence of Venice is doubted on many sides. (Dehio & Von Bezold, Church Architecture of the West, p. 339). The Church of S. Front at Perigueux with its five mighty domes arranged in cross form and supported by heavy pointed cross arches assumes a place of honor among these buildings. (The

domes of S. Front are marked by plain construction in cut stone and by horizontal courses in the pendentives). The principle of actual arrangement beside each other appears even more clraily in the Abbey Church of Fontevrault, as well as in many other mostly single-aiseld plans at Angouleme, Cognac, Limoges, etc

The transfer of the domes always indicating a central point, to churches progressive repetition was unnatural and forced in spite of other beauties, and therefore contributed as little as the tunnel vault.

c. Rectangular pendentive dome.

Far more alive showed itself the rectangular pendentive dome. (Fig. 14). It was erected in many places, in France preferably in Anjou, Maine and Touraine, in Germany at Paderborn and Knechsteden as in other places. It is mostly found over the intersection but also frequently over rows of vaulted bays. These d domes join at the four enclosing sides so simply and organically, that this must be regarded as a preferable solution, particularly if one considers that it adapts itself to a rectangular bay just as conveniently as to a square one. Since further on account of the spherical form is the construction possible without a centering, and one should not wonder that it was long retained in some places, when the cross vault had already become generally dominant. It even frequently adopted the ribs of the cross vault without abandoning the spherical surface, and the ribs then merely form an ornament as most a stiffening, b but are not the actually supporting parts.

d. Arrangement of transverse tunnel vaults.

Before passing to the last and final solution, there is still to be mentioned a not extended experiment expressed in the Church of S. Saturnin at Toulouse. It is a result of transverse tunnel vaults, as more commonly found over side aisles. Its transfer to the middle aisle shows a desire to obtain more light, without considering the effect of the interior was so disturbing, that no desire appeared for more general repetition.

Cross vaults over middle aisle.

The sole solution remaining was the cross vault. It appears surprising nearly everywhere, that this otherwise so frequently employed form was so long avoided for the middle aisle; still this had its weighty reason. Aside from the nature of materials and of the technics, a cross vault erected after Roman

art in this height and space required an abutting mass, which the middle walls of the basilica could not giva, and at the same time with their uniform thickness, they were adapted to receive a load concentrated at certain points. If men would create the abutment by a continuous increase in thi thickness of the wall or by a pier, then was lost again the long desired spacious combination of the three aisles. There might also be made many dangerous experiments, until they succeeded step by step in reducing the thrust of the vault and making the abutment more resistant without piling up masses. The aim was completely attained only when the Gothic vault and buttress system were fully proposed.

Besides these hindrances in the construction, there were difficulties opposed to the introduction of the cross vault in the arrangement of the plan. The middle ailse is wider than the s side aisles, and therefore as in Fig. 15 I always appear rectngular bays in a continuous subdivision into bays, either in t the middle or at the sides. But the Roman cross vault was unsuited to cover a rectangular bay., and also the transformation of the cross vault in the Romanesque period produced difficulties, if the lengths of the sides were quite different. Hence men sought to arrange square bays as much as possible for the three aisles, and came to the arrangement II, where each two bays in the side aisles correspond to a larger one in the middle aisle. This ground plan was the typical one for the vaulted Romanesque basilica in Germany. There alternated heavily loaded main piers with those less loaded and intermediate. Men sought to connect the latter with the principal vault by the use of the hexapartite vault, particularly in Northern France, about the middle of the 12 th century. Thereby originated the arrangement III, but which was dropped again at the beginning of the 13 th century. In Germany the hexapartite vault was especially erected on the Rhine, then at Bremen, Maulbronn, Limburg-o-L, but was little employed in general, and as soon as the development of the cross vault permitted the covering of rectangular bays, men generally to the most natural solution I, which soon became the general rule for the Gothic ground plans of churches.

Transformation of the cross vault for the rectagular plan. Experiments with the now favored subdivision into bays for

the middle aisle usually never stopped. Moreover since in covering the side aisles and no less in the arrangement of monastic and secular buildings men came again to the rectangular plan of a room, a transformation of the Roman cross vault only calculated for square bays could not at once exhibit durability. Men adhered indeed so long as possible to Roman traditions, but were compelled by necessity to abandon them more and more.

All essential solutions might be successively placed beside each other, than in general the old method of construction afforded for the vault of a middle aisle with transverse rectangular divisions. Since in the Romanesque period the cross vault was erected on a complete centering, it is useful for a clearer understanding to consider not the vault itself, but the form of its centering.

If not strictly proved, it is still probable that for a series of cross vaults the Romans first constructed a continuous centering of planks under the longitudinal tunnel vault (Fig. 16), and then first placed the centerings of the separate cross tunnel vaults upon thes, exactly as one proceeds today in vaulting small compartments in cellar vaults.

These technics were still employed in the first Romanesque period as proved by Schäfer (Centralblatt der Bauverwaltigen, 1885) very fully by the observation, that on such rows of vaults is lacking at one side a transverse tunnel vault, and that usually the ridges of two opposite tunnel vaults do not exactly meet.

Longitudinal tunnel vaults with side compartments.

It is now assumed, that the middle aisle of a basilica with rectangular division of the plan is to be vaulted. The inner longitudinal walls are already carried up high and attached to to them are the semicircular side arches. There is now to be established the centering for the main tunnel vault, which has the form of one half of a semicircular cylinder. On the continuous lagging planks of this half tunnel will be rested those of the cross tunnels, which are laid horizontally from the side arches. (See plan and cross section I in Fig. 17). These can form only low side compartments but not cross vaults.

It was only too natural for men to attempt to carry the side compartments higher by increasing the lengths of the planks. The highest point t of the section was then higher, but it could

never be at the middle of the vault, at the highest point being at the contact n of the tangent g h. (See plan of section II in Fig. 17). A cross vault then did not originate in this manner.

Accordingly with round-arched tunnel and semicircular side arches after the Roman mode might be produced a vault with side compartments, but never a cross vault. Alterations would be made, that might extend to the main tunnel vault or the transverse compartments.

The semicircular longitudinal vault is to be changed into a lower elliptical vault, as it more frequently occurred on the side aisles to equalize the heights of the crowns, Fig. 18, b but this could not actually come in consideration for the middle aisle; the thrust would thereby be much increased; when opposing it was just here a main question. Far more worthy of consideration is the form of the pointed tunnel vault, which at the end of the 11 th century and in the 12 th century appeared in many places on account of its favorable structural qualities. Combined with larger side compartments this allowed a section like a cross vault over a rectangle (Fig. 19). It is possible that the pointed tunnel vault was a link deserving consideration in the course of the development of the Gothic vault, but before it could afford opportunity in importand rebuildings, there were continued experiments in other places and especially in Germany with semicircular forms, to which we therefore return.

If the principal tunnel vault remains round, then must the transverse compartments be changed, either by introducing a new form of side arch or by the entire change in the curvature of the formerly cylindrical surfaces of the compartments.

Elevation of the side arches to the height of the middle of the vault.

The semicircular side arch was most simply changed by stilting it until its crown had the same height with the tunnel vault (Fig. 20 I). If the lagging planks were laid perpendicular to it against the surface of the tunnel vault, they formed a half cylinder, that intersected the great half cylinder in cross form. If an arch form so obtained must be termed must be termed a cross vault, still it did not correspond to the idea formed of it by men, for the groin lines (see plan) did not

lie over the diagonals, but rather formed recurved lines in t the plan (see plan), that were little attractive to the eye, and particularly must appear undesirable in a painting.

Men could not be contented with this vault, but must strive for regular groin lines. To obtain them, they could not take them as an accidental result of the intersection of the surfaces, but must start from them, first fixing them and thereby determining the form of the compartments. But this meant an important change in the technics of vaulting, for in place of the surface became the prominence of the line. If men would first fix the groin lines, it was then only a question of time when they passed to place under them diagonal centres, and abandoned the ancient mode of lagging. But they could not go quite so far, and at the beginning were perhaps satisfied to sketch the diagonal groin above on the plank lagging of the principal tunnel vault.(Perhaps by plumbind down from the line stretched diagonally). We assume this for the time.

Where lagging planks are laid from the groin line drawn in this manner to the wall surface, there result here side arches with the form of a vertical half ellipse (Fig. 20 II). The use of such elliptical arch curves is to be considered so far, as they already formed the transition from the semicircular form, and thereby cleared the way for the introduction of other forms of arches, particularly of the pointed arch.

Elliptical form of arches that are seldom built mathematically correct are very frequently found in Romanesque works with some attention, but are mostly changed into horizontal ellipses and also frequently are vertical; in the side aisle of S. Mary at Dortmund both appear at the same time, and in a side aisle of the districh Church at Paderborn the longitudinal tunnel vault shows a stilted ellipse as cross section. (The groin angles in the latter are quite irregularly curved).

If instead of the inconvenient elliptical side arch and stilted semicircle is retained (which was perhaps already arranged on the previously erected walls), then could also the lagging planks be laid from this to the sketched diagonal groins (Fig. 20 III). Then the planks are no longer perpendicular to the side arch, and the surface of the compartment no longer remains a regular cylinder. Men had thus freed themselves from the cylindrical surface, but when this once occurred,

nothing more stood in the way of giving the side arch any other form desired, for example that of the pointed arch, far preferable for other reasons (Fig. 20, IV).

It is evident that by means of high side arches could be produced a rectangular cross vault with regular diagonal intersection. Men were led to this to abandon the semicircular arch or to forsake the cylindrical surface of the compartment.

Rectangular cross vault with low side arches. Elevated t transverse compartments. Swelled compartments.

Men must give up entirely the old form of compartments, if they desired not to use high side arches, but in the original and always preferred case in the Romanesbue period, particularly in Germany, to turn to simple semicircles for side arches, littel or not at all stilted. Assuming that the side arches of a vault to be constructed were already built, and the tunnel vault inserted as a half cylinder, and further the groin lines were drawn on the plank centering, since they desired to have an exactly regular intersection of the compartmentr (Fig. 21). Then was to be laid the laggingfor the side compartments. That the end could not be attained in the usual way is already shown in Figs. 17, I, II. The planks abut against the longitudinal tunnel vault without reaching the crown. Yet if a connection of the side arch with the diagonal groins is forced by the lagging, than a part of these must penetrate through the surface of the tunnel vault, as shown by the hatched area on the plan in Fig. 21. The lagging of the principal tunnel vault thus can no longer extend through, and what is more important, the lagging of the transverse compartments forms a surface, which appears to hang down like a trough; but this form is ugly and is structurally doubtful. (See the different views in Fig. 21. The trough must be filled, whether by a layer of earth or an added centering or by both together. (A different direction of the lagging planks already aids in filling the trough). This addition can be carried high like a swelling, that was even necessary to a certain extent, if the groin is to be everywhere recognized as projecting beneath. In this manner is formed a domical swelled surface of the compartment. If this swelling had been once employed for both rising transverse compartments a b o and c d o, it was natural that on account of similarity it should be carried to the two others, aco and bdo.

Independence of the diagonal groin. Transition from the ellipse to the semicircle.

It was first assumed for the last vault, that in the longitudinal direction of the middle aisle were still inserted true cylindrical compartments; but this has now become without purpose. For these vaults were already established supporting centering arches beneath the groins, and the lagging rested on t the latter above the always existing cross arches, thus they extended through. But also the desire to give them the form of a continuous cylinder also ceased, and they could as well take a freer form, just as the rising cross tunnel vaults had. In other words cross and groin arches could be just as independent of each other in the longitudinal direction, as the side and groin arches already were in the transverse direction. I.e., the groin arches could now be shaped just as desired. This was again an important advance. The flat elliptical shape of the groin arch was a defect in Roman cross vaults, which the Byzantines had already invented, but which must appear as a difficulty in the middle aisle of the Romanesque basilica. Therefore men would so readily adopt no variation from the ancient vaults, as just this freeing from the strongly thrusting and also statically objectionable form of the ellipse, that was usually replaced by the semicircle.

For an elongated rectangular bay the transition to the semicircle made no very great progress, since the ellipse was here very near the semicircle. It must have had also a very great influence, that apparently men very poorly understood the laying out of elliptical centering arches, and already for this reason favored different forms. Frequently instead of the ellipse itself was recourse had to the stilted semicircle, which the Byzantines employed entirely for their stilted cross vaults.

The Romanesque cross vault with stilting and swelling.

Thereby was created the swelled cross vault, stilted in both directions (Fig. 22), that is to be regarded as the final result of the Romanesque treatment of vaulting. It has the same advantages as for the square bay as for the rectangular, and therefore is employed for both. Two factors constantly worked together in its development, the first being the difficulty in covering the rectangle, and the second was the need for lessening the thrust, the last being an important end for which

the first aided in finding the way. How far the precedent of the far earlier but substantially different stilted vaults of the Byzantines may have aided may remain an open question.

The origin of the stilted and swelled vault is frequently derived directly from the square bay without reference to the rectangle, and therefore the reduction of the thrust is regarded as the sole impulse for the transition from the elliptical to the round arched groins. The way is direct but too unreconciled, it contains a gap, that was first bridged when men took into consideration the necessary procedure by vaulting a rectangle, as such was attempted in the preceding.time. But it should not be denied, that besides the contemporary succession m must be assumed a constant alternation of advances, with each that are taken into consideration. Until for the history of o construction and of art equally important questions on the mediaeval development of vaults are fully cleared, must it still require very thorough studies. Unfortunately former drawings of buildings show by comparison with the reality very little confidence concerning the vaults. To correctly investigate the latter are required accurate detail drawings, for which the cooperation of many professionals would be desirable. Never should the particularly favorable restorations be allowed to pass in important works without accurately measuring the forms of the vaulting arches, their diameters and centres, as well as the forms of the compartments and all structural details from the buttresses, so far as they may be of value to publish.

Form of compartmentr of stilted vaults. Groin or channel in the groin lines.

To the stilted and swelled vault represented in Fig. 22, that is quite typical of the later Romanesque works in Germany, is always to be conceived that cross arches are added. Its groin arches as well as the four enclosing arches are semicircles, and they consequently are covered by an ordinary spherical surface. Between these six arches extend the four compartments, for whose form are three possibilities.

1. The compartments are so stongly swelled , that they lie outside the spherical surface, and there results a true cross vault with groin angles projecting beneath. In the section x-x of the diagonal view represented in Fig. 23 a is given the curve

of the compartment I given the larger scale in Fig. 23 c; at the point n appeass the sharp angle of the groin.

2. The compartments lie exactly in the spherical surface, then results no cross vault but a pendentive dome. But the diagonal arch does not project from the surface, as shown in the section II in Fig. 25.

3. The compartments lie inside the spherical surface. In this case and strictly taken are found no cross vaults, but a kind of cloister vault, and the diagonal angles appear when seen f from beneath, not as projecting groin angles, but as reentrant angles. See section III.

Vaults of the last kind are indeed not rare in the periods of the Romanesque and transition styles, and particulary often are found those in which the diagonal arches appear ar groins in the lower part and is hollows in the upper part, for example in the great church of S. Maria at Lippstadt, and in the interesting strongly stilted vaults of the district church at Paderborn. Fig. 26. In both examples exist no projecting ribs. the last are very suitable to make hollow intersections of the surfaces of compartments unseen by the eye, wherefore even the occurrence of hollows in Gothic vaults is not usually considered.

It it is desired with semicircular groin and side arches to obtain a cross vault with projecting angles of the groins, then is one driven to a strong swelling. The latter had thus in such vaults the twofold purpose to allow the groin lines to project and to avoid the trough-like sinking at the crown of the compartment. But the swelling was always a heavy addition, so long as one constructed the compartments on a complete centering.

When the form of the swelling, as mostly adopted for rubble stone compartments, was prepared for by a form of earth on the lagging, then must a considerable volume of earth be heaped. This was particularly great when the planks were placed as shown in the triangle d o g of Fig. 23 b. The addition might be reduced somewhat by giving the planks the positions given in the triangle g o c, that better equalizes the sinking at the crown. Yet the heaping still remains so considerable, that for many built vaults must be allowed 100 wheelbarrows and more of earth. Such a mass permits it to appear questionable that earth was the sole expedient; but if one must assume a filling of wood, the work of preparation was so much more elaborate. Where a s

suitable material was at hand, even in the Romanesque period freehand vaulting must already have been in use much more than is usually believed.

Gothic vaults with swelled compartments built freehand.

The centering of a swelled vault always remained a great difficulty, one must therefore regard it as a great acquisition, when men generally learned to construct the compartments in freehand. (See compartment masonry later). The independent construction of the projecting ribs on centering arches, and the resulting construction in courses of light swelled compartments without any centeringis to be regarded as the most perfected method of construction of Gothic. It stands higher than all which the art of vaulting had previously undertaken.

Gothic rubble vaults on centering. Avoidance of the swelling, pointed side and cross arches.

The compartments built freehand, in spite of their advantages, were only adopted where bricks and easily wrought limestone ((Isle de France) and also always tufa formed the material of the vault. Vaults of rough and heavy rubble were constructed on centerings until in the 15 th century. In these was again omitted the swelling on account of its difficult execution, but which was only possible by an alteration of the form of the v vault. The swelling resulted from the strong stilting, and the latter must be avoided. For this purpose to lower again the g groins would have been a step backward, and therefore the side arch was raised by stilting the semicircle, or better by the more pleasing pointed arch (Fig. 24). If the groin arches remained semicircles, then must the crown c of the arch be raised to the height of the middle, so that no drop occurred in the ridge o c.

By this vault the second condition is also satisfied, that the groin lines did not become hollows in spite of the omitted swelling. To have an approximately correct indication, whether groin or hollow is to be expected, it is best to draw the diagonal view of the vault. If in this ar in Fig. 24 the projections of the half arches b c and a d remain outside the diagonal arch a o b, then are to be expected projecting groins; commonly if they lie within the diagonal arch as in Fig. 23 a, then may one count on hollows.

In Fig. 24 the groin arches were drawn as semicircles. But

just for these pointed arches may have great advantages. Only with pointed arched groin lines is it generally possible to erect a raised cross vault without convex ridges (Fig. 25,right).

In Fig. 25 the left half shows a semicircular groin, and a convex ridge is not to be avoided there. At the right is employed a pointed diagonal arch, which permits a straight ascend-ridge o g. The possible amount of the rise is made if a tangent is drawn at o to the projection of the pointed arch.

The importance of the pointed arch for the groin lines is often undervalued. Even in important places.(Viollet-le-Duc andin the earlier editions of this work, the semicircle is regarded as the customary form of the groin). But more exact consideration shows, that here is to be sought an important reason for the introduction of the pointed arch! The Romanesque vaults at Lippoldsberg have pointed groins with straight rising compartments of sandstone. The vaults of the district cumrch of Paderborn (end of 12 th century) with round side arches show high standing groin arches very nearly pointed. The ridges of the compartmentshave a steep and straight inclination with a deflection at the top. Sketch in Fig. 27 represents the vault.

Also at Paderborn are also found other vaults with pointed groins and ridges rising in straight lines, thus in the cloister and the tower of the cathedral. Also on account of its arrangement of buttresses, the latter vault is found far above in the tower, and always to reduce the thrust, is carried so high that the angle at the crown is only about 110°.(Fig. 27).

It appears in the following of the development of the vaults of the 12 th and 13 th centuries, as again and again occurred discussions, that imperatively referred to the introduction of the pointed arch. Here only the most important of the reasons are mentioned, which are derived from the change in forms; to these are added the even more important one of strength. It is particularly the lesser thrust of the pointed arch against the abutment and its own tasteful form, which for most cases of l loading considered (even without a vertex load) comes astonishingly close to the theoretical line of support with very important advantages.

The adoption of the pointed arch forms one of the most important steps in the history of mediaeval construction. The view of laymen must be termed erroneous, that holds Gothic and the

pointed arch as inseparable, yet it is to be desired that the introduction of this form of arch indicates those stages of t the development of mediaeval art, which shows complete freedom from the old fetters and the mediaeval principle is brought to complete acceptance, and to develop every construction from c case to case out of the internal nature of the matter. To take up the old contention over the origin of the pointed arch must be scarcely advisable here, since this question has entirely vanished in comparison with the fact, that it is properly used.

In the preceding is followed briefly the step-like transformation of the cross vault from the Romans to the beginning of Gothic, and its further development in the Gothic period will receive a more thorough discussions in later sections. In the process of development indicated, the middle aisle played a striking part. It occupied itself with the execution of vaults of greater heights with the admission of light at the sides a and with less thrust, which further must be suited to a rectangular division of bays. But there occurred other places in the plan of the church in which were treated forms far more irregular than the rectangle, namely to master trapezoidal and polygonal forms of plan. It is advisable to make clear by at least some examples the inadequacy if the Roman traditions.

Vaulting the trapezoidal bays of the choir aisle.

As stated above, the middle aisle presented the first, but the choir aisle offered the second and greater problem in the vaulting of the basilica. The choir aisle is to be understood as the extended and curved side aisle, and it therefore required the same vaulting that the side aisle received. But from its curved plan resulted difficulties of all sorts.

If the side aisle was covered by a longitudinal tunnel vault, it was easy to continue this in annular form around the apse, but as soon as side compartments appeared, there arose the difficulty, that these were larger on the outer than on the inner circle. Fig. 28.

But if the cross vault (or even the transverse tunnel vault) was employed, then would the dilemman be still greater, for there resulted a trapezoidal bay (Fig. 29), whose outer side a b is longer than the inner one c d. Now if semicircles are erected on both sides and are joined by a connecting surface, this is no longer a half cylinder as before, but has the form

of a half cone widest outside. The intersections of this conical surface with the annular tunnel vault surrounding the choir form a cross vault of different shape.

There are three peculiarities for this cross vault, if there are excluded the experiments with elliptical and other forms of arch differing from the semicircle.

1. The centres r and p of the side and arcade arches in Fig. 30 lie at the same heights --- so that the ridge rises from n to m. The point of intersection is no longer at the middle of the annular vault (Fig. 30).

2. The ridge m n is horizontal --- and then p of the arcade arch is higher than r of the side arch, so that the capitals of the arcade are higher than those on the outer wall (Fig. 31).

3. The vault is as in the last case, yet the arcade arches are stilted, so that the arcade capitals are at the same height as the wall capitals (Fig. 32).

The last arrangement was the most satisfactory, but it had the defect, that the upper conical surface intersected the vertical intrados in the oblique line o p. Thereby the vertical surface received an ugly appearance. If it is desired to have this intersection o p horizontal, then the masonry block below o p must have a trapezoidal plan x, instead of a square plan x'. See Fig. 30. This expedient was actually employed in the churches of the 12 th century, but it let to an ugly trapezoidal plan of the capital aside from other faults. It is evident from the preceding, that the forms of vaults based on the ancient Roman traditions here led just as little as for the middle aisle to a satisfactory result generally usable. Likewise when There were added projecting cross, wall and arcade arches, would the weakness at most be concealed but not removed. When m men passed to the Romanesque vaults represented in Figs. 22 and 23, this could also be employed over a symmetrical trapezoid (as generally over every ground plan inscribed in a circle). Fig. 34. Both the two groins and the four side arches were semicircles. But besides structural faults, the form has --- see below under the forms of the elevations of the arches of the cross vault --- the esthetic defect, that the intersection of the groins lies sidewise from the highest point of the vault.

Freedom of the form of the Gothic vault in plan and elevatio

A solution resulting from all requirements for the choir as

aisle and the middle aisle first occurred, when the development of the vault had found its highest aim in the Gothic cross vault. With the Gothic vaults came entirely to light a principle, that step by step tirelessly included in itself nothing less than complete freedom of form. For this form of vault is there no further restraint in plan and the development of the elevation. (Fig. 25).

The vaulted bay may have any form of plan. The enclosing arches can be determined independently of each other as round, pointed or stilted arches, indeed may also have the form of a mathematically formed line of support.

Exactly the same is true for the diagonal arches. The same freedom further exists for the mutual heights of the keystone and crown of the arch. Finally the ribs may be multiplied in an unconstrained manner, and combined in the most wonderful s star and net figures. Generally limits uere fixed for the Gothic forms only by the laws of the equilibrium of forces and by the requirements of beauty.

These results in the treatment of forms are astonishing, and entirely equal in rank are they established beside those relating to the mode of execution, and which terminate in the final aim to limit the mass of dead material as well as the amount of the rough labor.

Contrast of Roman and Gothic methods of construction.

To correctly understand the aim of the mediaeval method of construction, it is well to contrast it with the Roman.

Their mode of construction (formation of a massive connected body) allowed to the Romans a tolerably great freedom in the form. But they did not utilize this liberty, yet placed the f form in fetters for architectural reasons. For arches and vaults rose the semicircle to an invariable typical structural form, that established itself in the same line with the columnar orders transmitted to them by the Greeks.

The middle ages struck out the contrary path; the form was loosed from this external restraint, its shape is freed from artistic creations, but for this it conversely surrenders just the strong domination of the construction.

The Barocco style rejected both restraints, it loosed itself from strict form and construction, in whose place it set in t the foreground artistic caprice.

For Roman architects was first fixed the architectural form of its construction must be suited to it. The Gothic master m must develop the form from the construction and then give it the artistic stamp. The latter perhaps had the most laborious way, but only thus could he solve his problems in a way impossible to the Roman.

The difference particularly occurs in the limitation of the masses. While Roman vaults seldom exhibit less than 1.2 m and frequently 2 to 3 m in thickness at the crown, and even Romanesque vaults of medium span have a thickness of 40 to 50 c m and more, Gothic vaults are built with a moderate execution of the ribs and even over wide rooms, that require a thickness f for the compartments of only 10 cm or less. The economy in the mass of abutments has an equal advance. Masses generally only occur where forces act; accordingly the perfected Gothic architecture shows a clear separation between the supporting skeleton and the filling surfaces.

That is followed from above downward. In the vaults the compartments form light filling surfaces, while the ribs have to support, and they transmit their vertical forces to the piers, whose thickness only needed to be small; but on the contrary the horizontal thrust was transferred to strongly resting buttresses and flying buttresses. The outer wall only has to enclose here, and according to its purpose it consists of stone or of a freely extended glass surface.

The effect of the forces in both structural arrangements must be regarded as thoroughly different. A true Roman structure f forms a single lifeless and quiet massive body, that is to be compared to a hollowed rock, or if we will, to a terra cotta vessel. The whole is held by internal forces, that depend on the strength of the material.

The Gothic structural system is more like a living and elastic system of numerous separate bodies, that are held in a fixed condition of equilibrium by forces acting on each other. If an external change of form occurs, for example if the foundation wall sinks slightly at one side, the Roman work breaks into fragments in the same way as a vessel, on the contrary the Gothic structure will rather show a displacement of compression in different parts, that in a somewhat changed condition again seeks to assume a quiet position.

The contrast of the two great structural divisions of Roman antiquity and of the middle ages is accordingly decided, but it easily finds its foundation in history. The Romans were a people dominating the world, and they had at command inexhaustible wealth and numberless enslaved laborers. For them it resulted from the nature of the affair without considering the nature and means of building, that a thoughtful master was himself able to erect mighty structures in distant provinces by thousands of mostly unskilled laborers.

The middle ages created under different conditions, the mean were moderate and the workmen were paid. Yet if still great w works were to be undertaken, then must the amounts of the roug mass and of work be restricted, no structural member must have anything superfluous. But this was only attainable by a perfec ly developed system of construction carefully worked out by th master, and executed by known sympathetic workmen. What the Romans could do with abundance of power, was here accomplished by the work of the intellect.

2. Construction of Vaults. General.

Surfaces of Roman vaults. Surfaces of Gothic vaults.

The most important difference of the Roman from the Gothic vault lies in the relation of its formative surfaces to the e enclosing lines. In the former are these surfaces, being the enclosing surfaces of the body forming the entire vault, the half cylinder or hemisphere,are the determining parts in the manner, that in cross vaults as well as in the dome placed over the square (the so-called Bohemian or segmental vault), the limiting lines are formed by sections of this body. According to the Gothic principle the area to be vaulted is first subdivided by lines resulting from the system adopted, and ove these lines are turned the separate arches, that as ribs of th whole receive between them the masonry of the compartments acting as the covering, and support it.

Let there be in Fig. 36 the ground plan of a Roman cross vault, which then in elevation cosists of four similar sections a b c, b c e, etc., of the half cylinder. Over the sider a b, b c of the room are thus turned semicircular arches and a section f g or h ithrough this surface of the vault parallel to these sides forms a segment of the same semicircle, by whose highest point is given the height of the diagonal arch, so

that the same is fixed by these segments. The erection occurs on a centering, that in a way represents the whole of the vault, and whose external surface therefore corresponds to the enternal surface of the vault. On this outer surface is then laid the stones or bricks forming the vault, either set radially (Fig. a), or on it according to the ancient Roman method is laid concrete composed of mortar and broken bricks.

Masonry vaults. Concrete vaults.

In the first case the separate stones either have a wedge shaped form, i.e., their surfaces diverge in the direction of the radii, and the mortar bed between assumes the same form (Fig. 37), or the whole is made of cut stones or shaped bricks; on the other hand if only ordinary bricks are at hand, then as a rule these retained their rectangular shape, and only the mortar beds acquired a greater divergence outward.(Fig. 37 a). Then the mortar beds hold the bricks in place, and the beds between them cannot slip downward.

In concrete vaults the shapes of the inserted stones are just as irregular as the binding mass of mortar, and just in this irregularity lies the durability of the whole, when the mortar penetrates the crevices and between the stones and broken bricks, binding the whole into one mass.

According to the first mode of construction is therefore ensured the position of each stone, and the centering can be removed as soon as the whole is closed, and in the second when the entire mass has hardened. Therefore there results from this properly only a covering composed of inorganic bodies, that only has the arched form so that the load not only opposes the relative but also the reacting strength, while over a smaller area could also be made of them a plane covering, and actually in the 12 th century even window lintels were so constructed.

Erection of the dome.

The construction of a dome may likewise occur in both ways on a hemispherical centering for placing concrete or by actual masonry set on it.

In the manner of the last construction the special peculiarities of the hemisphere introduce and make possible an important simplification. The tunnel vault and the Roman cross vault developed from it a separate straight horizontal courses, that extend in the half cylinder produced by the semicircle or seg-

segmental, and only when this is closed it then obtained an a assured position. A stone of such a course is shown by Fig. 38. On the contrary in the dome each of the likewise horizontal courses forms a circle. Each stone of such a course receives about the shape shown in Fig. 38 a, and extends as a part of the semicircle forming a section of the dome and then of the circle formed by each horizontal course. It also already acquires an assured position as soon as this course is closed. It thus can be done without a centering, and then that is generally superfluous. Conceive such a dome built of bricks, and in the lower third the courses so nearly approach the horizontal, that the separate bricks will continue to lie on each other without binding mortar. Further up the mortar acts, so much the more readily as it is made thicker and the work goes more slowly, so that it can set. But at the same time with each upper course the radius of the circle lying in the horizontal plane becomes smaller, so that if the binding strength of the still wet mortar no longer suffices, the separate bricks can be held in place in other ways. Yet always the closing of the dome remains a difficult work, from the endeavor to keep the bricks in their places, as well as by the need of fitting them to the uppermost circles struck with smaller radii. For the entire construction is needed a means that shall hold each separate brick in its place. In Romberg's Journal for practical Building, the deceased Lassaulx gave such, which consisted in fixing a rod at the centre of the dome that swung in horizontal and vertical planes about that point, thereby determining by its contact the place of each stone.

Construction of pendentive domes.

The before mentioned conditions of stability suffer a change, if the dome is turned over a square, in its lower courses. Such a dome is shown in Fig. 39 in plan, in section through e g in Fig. 39 a, and in perspective in Fig. 40. There the square a b c d is the area to be covered by the dome, the radius of the dome being a C, and the section on the line a b through it is a semicircle. While in the dome turned over the circle a horizontal course forms a complete circle in itsilf, whose radius diminishes in each successive course, this is then the case here if the courses correspond to the circle inscribed with in the square, i.e., above the semicircles turned over the sides

of the square, thus to the course indicated by f g in Fig. 39a. All courses below f g form only circular arcs, which extend between the sides of the ground form and exert their thrust directly on them. (Note). They will do this in just the same way as if their radii, instead of from the centre C were struck w with entirely assumed radii, i.e. for example, the lourse lying at the height n o formed the segment h l k or h m k instead of h i k. Therefore retaining the centre C for the courses lying in a horizontal plane is only required in regard to the c commencing courses at e m, which must find their supports on those beneath them.

(Note). It is to be considered, that as might appear from t the preceding, that the little horizontal ring courses do not extend their ends between the walls. In the longitudinal direction of the courses may indeed also occur a ring stress, that exceeds the particular counter pressure of the dome, but it p passes down in a meridional direction from one course to another, until it enters the enclosing walls. See page 56 below.

Combination of qualities of dome and cross vault.

If one now conceives that the two previously developed systems of the cross vault and dome are combined together, then gradually result all the properties of the Gothic vault. It is the object of this combination to give the cross vault the peculiarly assumed location of each course in the dome, or conversely to give the dome the division of the great surface into four smaller ones by the diagonal arches, and thus to adapt both to easier execution. Fig. 41 shows first the horizontal section through the cross vault in Fig. 36. In Fig. 39 is stated that the lower parts or the feet of the dome extend between the arches turned over the sides of the room, as shown in perspective in Fig. 40. Likewise could these extend between t the arches turned over the sides and the diagonals of the cross vault; hence the surfaces of the compartments in plan in Fig. 41 are enclosed by segmental arches instead of straight lines, as shown in Fig. 41 a. At once when the location of the point b lying in the diagonal arch is ensured, also the location of the two courses a b and b c are so, and thus the difference in execution in comparison with the dome only consists in this, that while in the latter one only required centerings for the arches turned over the sides, here such are necessary for the

diagonal arches also. While here all arches remain unchanged both over the sides and diagonals of the room, there enters into the conditions of stability of the entire vault a substantial alteration. In Fig. 41 the separate stones, as already stated, form only a part of the semicircle or segment generating a part of the cylinder, but it also first rests on the diagonal arch, where it meets the arch to which it belongs. Thus the stone first loads the diagonal arch at t. On the contrary in Fig. 41 it extends in the segment a b and thus rests on the s stone of the diagonal arch placed at the same height, and transfers its load downward in the latter. (Note).

(Note. The last assumption is but partially correct. See on this below Figs. 116 to 120).

Semicircular groins.

While then according to Fig. 41 the lowest point of the diagonal arch has the full load of the semicircle, each more projecting point of the smaller segment and finally the crown have nothing more to bear, the converse condition appears here, when the segment of the course directly rests on the vertex, but n not at all on the lowest point of the masonry of the compartment, but is only loaded by the pressure of the arch itself transmitted downward.

To resist this very considerable loading of the vertex is little adapted the diagonal arch line of the Roman cross vault produced by the intersection of two half cylinders, in so far as shown by Fig. 36 b n d, for a considerable length at the ridge n approximates the horizontal, and this is weakest just where its load is greatest. Therefore it must be replaced by a true arch line and is by a semicircle. Now always retaining t the square plan, if we assume the semicircle as the diagonal arch and the entire vault is shaped in the Roman manner, that gives it as actual section line, then will the rectangular section through a quarter of the vault be a vertileal half ellipse, developed in the opposite way from the semicircle. In Fig. 36 the elliptical diagonal arch is developed from the semicircle shown over the side and generating the vault. Such vaults are also found in some English Gothic works, in the transepts of the foundation church at Wetter (Note), and if we do not err, the collegiate church at Mantes. They always exhibit a still incomplete development of the Gothic system, whose natural

sequence led to making all arches true circular arcs, both over diagonals, sides and the ribs of the entire vault.

Note. According to Schäfer (Zent. d. Bauw. 1885) not at Wetter but in Godehard's chapel at Mayence.

If now the latter arches are again conceived as semicircles, we return to the dome, and only the horizontal section of the compartment surfaces can make the distinction. But the crown of the diagonal arch as in the dome rises high above the arches struck over the sides of the room, and there occurs a loss of height, even in square and still more in rectangular plans, a loss of height above the latter arches, corresponding to the difference between the side and diagonal. Vaults of this kind are found in the cathedral at Trient. (Note). To avoid the loss in height , equally objectionable in practical and esthetic respects, it is necessary to make the heights of the arches independent of their spans, and first to give the arches turned over the sides a greater height. (Note).

Note 1. p.22. Mediaeval monuments of art in Austrian Empire.

Note 2. p. 22. The loss of height is relative, according to whether one starts from the vertex of the side arch or abutment of the vault.

Pointed arches over the sides.

But the before menticned loading of the crown had already led to giving a form strengthening this point of the arches turned o over the sides of the room, thus substatuting the pointed for the round arch. On the origin and sourch of this form of arch, so many opinions have been already expressed, that we avoid r risking a new hypothesis, when this by far not have the importance assigned to it, and a completely Gothic vault can indeed be conceived without a single pointed arch.

Position of courses in the compartments.

But in the choice of the radii of the pointed arch lay a means sufficient for attaining any desired height, and regulating the proportions of the height of the crown at pleasure, so as to avoid any loss of height.

In the Romanesque tunnel and cross vaults the beds of the s separate courses lie parallel to the ridge joining the opposite vertices of the arches. The same direction of the beds was also at first retained in the Gothic cross vault, only being replaced by another in the late brick structures. This is assumed

in Figs 41 and 41a. Fig. 42 then shows a view of a vault built in this way to about half its height, where the voussoirs of the diagonal arch were either cut with an angle as in Fig. 42a, or received a hook shape as in Fig. 42b. In the first case both the through joint and the acute form of the stones formed a defect, and the last was increased in the courses of the compartment were segmental arches as in Fig. 41a. In the latter case the preparation of the hooked stones was tedious and afforded no corresponding utility, since the bond of the surfaces of t the compartment thus formed over the diagonal arch were not at all necessary. Accordingly it was best to leave the diagonal arch to itself, and to shape and to use stones set radially as in Fig. 43, so that the separate courses of the compartment c could rest against it.

Projecting ribs.

Thereby the system of ribbed vaults already invented, and it required only a strengthening of the diagonal arch and the adoption of an independent form for it, to pass from that of Fig. 43 to the shape of Fig. 43a. In accordance with the distinction of the Gothic vault from the Roman given above, there are established as characteristic peculiarities of the former.

1. The forming of the courses of the compartment in segment-arches, i.e., swelling them.
2. The regulation of the heights of the separate arches.
3. Their independent execution and treatment.

But further will appear there what is said, that the Gothic cross vault combines in itself the earlier principles of vaulting of the Roman cross vault and of the dome, and represents itself in a certain measure as the necessary consequence of them.

Names of the parts of the Gothic vault.

Let Fig. 45 be the plan of the room to be vaulted, in which is given the arrangement of the vault. Then the form of the p plan, here the two rectangles a b c d and b d e f, are termed bays of the vault; the arches a b, b e, a e, e f etc., formed over the sides of the bays are generally called side or border arches, or side arches so far as they are closed by walls. Arches separating adjacent bays like b d, that occur instead of the wall a c, are named cross or transverse arches, or if they separate two aisles of churches are dividing or longitudinal arches. Over the diagonals of the bay lie the diagonal or groin

arches, that in the simplest case are lines formed by the intersecting surfaces of the compartments and are well named the groin lines. If they project from the surfaces of the compartments as more or less richly moulded members, they are termed ribs, and thu according to their location on the plan are cross ribs, groin ribs and side ribs. The highest point of the arch is the crown. The length of the ground line over which is turned the arch is the span, and the height of the crown above t the springing is the rise. For example, men say that the arch a b has 5 m span and 3 m rise. The vault surfaces extend between the arches mention are the compartment surfaces, or taken bodily are the compartments, the segmental arch in which the curve of the compartment is vaulted is called the swelling.

In complicated plans of star and net vaults the separate arches as a rule are not named, all ribs or groins being designated as the framework or skeleton of the vault. Yet here are also dossible distinctions between main, intermediate and ridge ribs, etc. The cut stone in which two or more ribs either intersect or meet is termed the keystone or boss.

3. Simple Cross Vault.

Forms of arches.

The Gothic cross vault allows the greatest freedom to the d different arches in the development of their elevations. When the single fundamental condition --- the equilibrium of the forces --- is satisfied, each separate arch may assume its own independent form. Accordingly the vaults of the Gothic exhibit the most varied diversity. Besides the semicircle (Fig. 41 I) the most common forms of arches are the more or less slender pointed arch (II, III), and the stilted or raised pointed arch (IV). The side of the pointed arch is chiefly struck from one centre, but sometimes from several (Figs. 48, 49). For lesser rise prevails the segmental arch (V) and the depressed or broken arch (VI), the latter especially in the English and also in secular German Gothic. Finally occasionally occur the ellipse, oval, horseshoe and others. Predominant is the pointed arch on account of its many qualities.

Equality of radii. Height of crown.

But with all the freedom in the form of the arch, definite considerations lead to bringing the arches into legitimate relations to each other. These appear first in regard to the

radii used in striking the arches, then concerning the corresponding height of the crown. In the first case the nearest construction is that, according to which all side arches are struck with the same radius as the groin arches. See Fig. 45.

The diagonal arches as here assumed are semicircles and are revolved down beside the diagonal. For the end b are laid off the sides a b and a c of the bay on the diagonal at a′b′ and c′b′, and above are erected pointed arches with the radius of the semicircle. The left centre of the pointed arch falls at the centre of the semicircle C, the right hand points lie on the ground line at C′ and C″.

In this construction all arches have exactly the same form in their lower parts, so that as shown by the Fig., they coincide in one half. This shape offers great advantages for the beginning of the vault, giving it a regular appearance and makes its construction easier, especially if numerous members separate in fan shape.

But to the general use of this arrangement were usually opposed difficulties. It is first embarrassing that the height of the crown of the arch is fixed by it; the crowns of the side arches are lower than the middle of the vault, and they also themselves differ in a rectangular vault, indeed so much the more, the more the plan to be vaulted varies from the square. But at the same time, for example, if the sides of the bay are in the ratio of 1 to 3, in b c d 1, the arches struck over the short sides assume a very pointed form (lancet). (See b S″ e in Fig. 43.).

Such a form for side arches has not exactly structural objections and affects only the possible insertion of a window, but those defects appear more decidedly if one conceives that the wall b c is replaced by a cross arch, which is concentric with the side arch and receives a still pointed form of inarados. But here will be enhanced in an overpowering way the characteristic peculiarity of the pointed arch, and by a load or force on the haunch will be transformed into a force acting on the keystone upward, that again requires to be neutralized by a loading on the crown. Even more does such a fault make itself felt, if the side thrust of this arch p q acting at e opposes one i i of much wider span. Not only will the play the part of a force acting on the haunch of b e and receive the outward

force, but it will find no resistance in the side thrust b e reduced to a minimum, and therefore makes necessary a substantial increase in the dimensions of the pier e.

The dependence of the height of the crown on the choice of the radius can thus easily become inconvenient, and it may even be entirely necessary to fix first the height of the crowns of the separate arches according to other definite aids. Those d different reasons may require that either all crowns must be at the same height, or that the crowns of the groin arches and thus the middle of the vault be higher, or even that the vertex of one or of several side arches rise higher than the crown of the diagonal arches. To justify the requirements on both sides, men have attempted to fix the height of the crown according to the requirements, and yet to strike all arches with the same radius.

In the Gothic A B C book of Fr. Hoffstadt (Frankfort-a-M,1840) is a method applied for this purpose, which is explained in Fig. For the side arch with span b e, the crown is fixed at i, for example here at the same height as the crown of the diagonal arches. Then both branches of the pointed arch are struck with the radius of the geometrical arch from the centres k and l.

The arches cut the verticals at the sider and thus take a f form corresponding to the Moorish horseshoe arch. This form of arch is little to be recommended, which but occasionally was constructed in the Gothic period as in Canterbury, for example, and may be avoided by changing the arch below m into a straight line. But then results a stilted broken arch, just as unsatisfactory and is much better replaced by a regular pointed arch.

Since by the construction above the desirable uniformity of the springings of the arches is not attained, but otherwise few advantages result from uniformity of radii, this experiment must be regarded as useless.

Another method of obtaining equal radii, with close heights of construction, places the centres of the larger arches below the base line, whereby result broken arches (Fig. 47). The appearance of the latter for a slight drop of the centres is not very disturbing, and statically it is even favorable. The desirable uniform springing of the arches is indeed also not attained in this way.

Compound pointed arches.

Worthy of consideration is a construction, that already since the end of the 13 th century found great use in English Gothic-it is based on this, that each arch is composed of two parts with different radii, indeed so that all lower parts have the same radius. Fig. 48.

The lower parts a b_1, a b_2 or a b_3, are all struck with the same radius from the centre o. On the contrary the upper parts have their centres at c_1, c_2 of c_3. The crowns are placed at the same height, as a rule in the rich English vaults.

Thus it is possible to obtain uniform springings for the arches and also to be able to fix the heights according to pleasure for the crown of each arch. The frequently recognized form of arch, which naturally carried from the vault the concentric line of the window, thus does not lack a certain practical justification, though statically this form is less favorable than the ordinary pointed arch.

It would not be objectionable where permissible also to take the form of the pointed arch sketched in Fig. 49, where conversely the upper part of the side of the arch is struck with a smaller radius, for it is statically favorable and is also en-entirely staisfactory to the eye with a small change in the r radius. Viollet-le-Duc asserts in his Dictionary, Vol. VI, p. 29, that pointed arches frequently occurred in the 12 th century, whose sides at their middle part are struck with a greater radius. Likewise could a statically favorable form be obtained thereby.

Stilting.

In general it is not advisable to assign too great importance to fixed theoretical rules of construction, but one should rather first be guider by a regard to beauty and the actual practical requirements. Most reach the aim by the ordinary pointed arch. If one neglects the uniformity of the radii, it will be easy to give the arches any desired form, and if necessary to afford any desired height by stilting.

For example, if it be desired to open the side arch by a window or a free opening with a fixed shape of arch, then the side arch is properly drawn concentric as much as the desired height of the crown requires. In this Fig. it is assumed that the side arch has the same height of crown as the groin arch represented with it should have. The difficulty that may be caused by stil-

stilting for the springing of the vault, etc., will be discussed at the proper place.

The development of the elevations of the arches for several different vaulted bays adjoining each other, such as occur in churches with several aisles, particularly makes careful judgent essential. There can either occur a beneficial graduation of the heights, or if the existence of an upper floor or any similar reason compels this, the crowns are made the same height. The choice of different radii and the use of stilting always leads to the aim. Naturally must static requirements and the difficulty of forming the springings (see that) will not be left out of view.

Vaults over irregular bays.

Bays of trapezoidal form.

Irregular bays require special consideration. If the plan of the room to be vaulted is a trapezoid as in Fig. 51, then the groin arches cannot be turned exactly over the diagonals, since these will consist of two very different branches, the smaller one either being stilted, or as in Fig. 51a must be struck with a far larger radius. But the structural difficulty results, that the larger half presses over the smaller, so that the stability may be endangered. Therefore the crown must be transferred from the intersection C of the diagonals toward the longer side, about the middle of the middle line e f at C′, or better a little farther to the geometric centre or even the c centre of gravity C″ of the trapezoid. Then the four halves of the groin arches will have approximately equal stresses. If one desires to go farther and to place the crown about over the p point g, which is equidistant from the four angles, then would be obtained four entirely similar groin arches, but equilibrium would now be disturbed in the opposite direction. Now would the total thrusts of the arches d k and c g exceed those of the t two others, and thereby the crown would be pressed toward the longer side. Various experimental arrangements are shown by the middle ages at the time, when it was necessary to give the trapezoidal bays of the choir aisle appropriate groin vaults. (See preceding page 16). Thus in the choir of the cathedral at Langres (Viollet-le-Duc, IV, p. 70) the groin arches are still turned over the diagonals, and they had the form of the semicircle. Hence their intersection lay far beneath the crown,

so that the pendant extending downward had an inclined position.
It frequently occurs, that the groin arches in projection on the ground had not four straight but broken lines. Aside from this, that already by the irregular intersection of cylindrical or conical surfaces, this form often resulted of itself, (see Figs. CC and 20 I), it is sometimes employed intentionally in Gothic ribbed vaults, indeed for two reasons. Either because men wish to have two similar springings for the adjacent compartments, and therefore the ribs are allowed to commence in the line bisecting the angle, or because they are wish to avoid a sidewise projection at the intersection of two unequally thrusting compartments. The frequently occurring so-called spiral ribs in the net vaults of the late period will be mentioned late

Entirely irregular plans.

For entirely irregular plans (Figs. 52, 53), whether they b have four or more sides, as a rule we proceed best by placing the keystone over the geometrical lentre or even the centre of gravity of the area.(The latter can be found with sufficient accuracy by cutting the area out in thick paper and balancing it on the compass point). But all groins having different lengths, it is best to determine the form of the elevation for t the longer, afterward those of the others.
Similarly but in a different form is theated the vaulting of a triangular bay.

Triangular bay.

This first develops from the simple needs. Let a b c d in Fig 54 be the area to be vaulted, which is divided by the cross arches e f and g d into rectangular bays so that the triangle g b d is left. Or there may be a rectangular area a b c d in Fig. 55 to be vaulted, against whose longer side are placed partition walls e e, f f and g g. If the outer walls of the roo are not sufficiently thick to receive the thrust of the vaults, the partition walls must serve as abutments, thereby compelling the separate bays to take the triangular form of plan e a g, eg f, etc. The sacristy of the church of Ss. Peter and Paul at Stettin exhibits an approximately square plan divided in triangular bays (Fig. 56). Here the addition to the church by a side entrance m seems to be the chief reason for inserting the fifth support e. Another occasion for this form of plan may result from the larger plans of choirs with aisles, that will be ment-

mentioned later.

The erection of the vault over such a triangular bay may occur in various ways. Either the components directly extend to the three side arches and intersect above like hip roofs (Fig. 57), and as for example such as occur on the choir aisles of the cathedral of Paris and of Notre Dame at Chalons, or the triangular plin is further divided by the three lines a h, h g and h e in Fig. 55, which are the projections of the proper diagonal ribs, while the arches turned over the triangular sides appear as cross arches. A very beautiful vault of the last kind is found in the lower hall of Römers at Frankfort-a-M. Figs. 57 and 58 show the contrast between both forms of vaults in perspective. In the latter may occur the describing of the arches in the same manner as for the cross vault with four sides, so that one begins with the construction of the diagonal arches, which if the triangle is equilateral may again be quadrants. Both forms of vaults may be combined in a vault with t the plan given in Fig. 55, in the way that the longer triangles a e g, etc., are like Fig. 58, and the the smaller ones a e c left at the sides be vaulted like Fig. 57 on account of their smaller size. The hipped vaulting on the corners employed there can also be transferred to bays with four sides, and then originates the interesting but seldom used form of the diagonally placed cloister vault.

Flat arches of vaults.

Where height is lacking, as particularly the case in utility buildings, there can the arches of vaults be made segmental instead of semicircular or pointed arches, or also by the broken arch much preferred in secular English Gothic, i.e., pointed arch with broken haunch. In construction such cross vaults agree with those already described. For example, if in Fig. 59 the arch a g e is the groin line, then with the use of the same radius can be constructed the side arch over a f' as a broken arch, or to reach the same height at crown as drawn at the right, over the side a f may be turned a segmental arch with a smaller radius.

4. Vaults with a combined System of Ribs.

Hexapartite and octapartite vaults.

The hexapartite vault.

In the 12 th and 13 th centuries is found the system of the

hexapartite vault. In the Norman and northern French works as well as in Germany in the cathedral of Limburg and other places. Its origin is connected with the entire arrangement of the ground plan (see Fig. 15, III), and it was again generally abandoned with the progressive development of Gothic art. Fig. 60 shows the plan and Fig. 61 is its perspective view. It is formed over the middle and transverse aisles of a basilica, and it chiefly has a square plan, that corresponds to the breadth of two bays of the side aisle. It differs from the ordinary cross vault in that to two diagonal arches a b and c d is also added a third groin arch e f, that finds its supports on the intermediate piers a and f. Hence the latter not only serve as supports for the side aisle but also for a part of the middle aisle. The longitudinal walls are each divided into two side arches, whereby the entire vault contains six triangular compartments. The compartments e C b and a C d are ordinary compartments of cross vaults, while the four at the side vaults d f C, b f C, etc., receive an unsymmetrical form that is best realized by a horizontal section made at a certain height that shows the parts hatched in the plan.

The development of the arches is indicated in the ground plan. The groin arches a b and c d are semicircular according to rule, the partial groin c f must naturally be an arch of the same h height. For the six round arches it is on the contrary free, either to bring them to the same height (Fig. 62) or to leave their crowns lower (Fig. 61). In the oldest examples sometimes occurs the form of the stilted semicircular arch, which was v very soon replaced by the pointed arch, much more suitable for this form of vault. The surfaces of the compartments may be straight or swelled, according to the requirements of the form or of the execution.

Figs. 62 to 62c illustrate the development of the elevation of a hexapartite vault with stilted side arches. Fig. 62 represents the longitudinal section, 62 a and 62b show plans at different heights, while 62c makes clear the form of the lower p pieces of the partial groin. In consequence of stilting the side arches a vertical wall is placed beneath and behind the partial groin, that first farther up passes into the vaulting of the compartment. The thrust that acts on the intermediate piers of the hexapartite vault is manifestly much less than

that acting on the main piers.(Usually but 1/3 as much). Therefore the former require lesser dimensions, as in the cathedral at Limburg, the cathedral of Laon, the church at Mantes, or if the dimensions of the pier are not determined by the thrust of the vaults of the side aisles, it may omit the artificial ensurance by flying buttresses. Hence where these assumptions occur, where either the pier is weaker or the arrangement of flying buttresses is difficult, where otherwise the arrangement of this hexapartite vault would be nearest the execution elsewhere of the system of the oblong cross vault.

For example, we meet such conditions in the arrangement of the transverse aisle. Let Fig. 63 be the plan of such low ... side aisles and oblong cross vaults over the middle aisle. The thrust of the vault of the middle square against the transept pier b acts against the clearstory walls of the transept and middle aisles, and against the vault of the middle aisle on t the aisle pier a, the flying buttress thrown from a to c. On the contrary there opposes the thrust acting on the point d in the direction d c no wall of sufficient height, and just as l little can a flying buttress be arranged at d, unless the window c d is omitted, and finally from d to c is possible a flying buttress to strike the buttress at c, thus perhaps overthrown. Therefore it is next to reduce the thrust of the vault at d, and this occurs just by the arrangement of a hexapartite groin vault over e i b b of the given plan, as found in the c cathedrals of Paris and of Beauvais. It is possible that in this plan is to be sought the first impulse for the development of the hexapartite vault.

Also for certain kinds of choir plans, whose investigation we must therefore anticapate here, are afforded allied arrangements. If the choir plan adjoins with a half polygon, for example with five sides of the decagon (In Fig. 54), then the natural junction of the ribs lies at the middle of the base of the polygon, and thus at c. But to the side thrust acting here is only opposed the width a b of this rib, an insufficient resistance, if the adjacent rectangular bay of the vault is formed on the system of the oblong cross vault. Therefore this system must be avoided, and this occurs if the ribs from d and e extend to c instead of diagonally, so that the bay a b c d takes the form of a hexapartite cross vault, while the next one is

covered by the usual cross vault. Such arrangements are often found, among others in the church of S. Elisabeth at Marburg and the collegiate church in Wetter.

Just as the arrangement of the hexapartite cross vault is b based on the insertion of a pier in each of the two sides of the vault, there results there the insertion of one pier in each side of a square the octagonal cross vault, in which likewise the compartments c C b, a c d (Fig. 60) are also halved. Such an arrangement of piers occurs where the western towers are connected with the plan in five aisles, so that the width of the tower is equal to that of both side aisles. Then indeed if as in Cologne the lower room is divided and includes a chapel besides the entrance, there results a ninth pier at the middle of the square, and the plan of the vault in four equal bays. But where the interior of the tower is entirely united with the interior of the church, as in the cathedral of Paris, the middle pier is superfluous without any special plan of the tower, and there results an octagonal cross vault. A peculiar example of this kind is found in the central tower of S. Maclou in Rouen, whose vault is raised two stories above the vaults of the middle aisle, so that from the church is had a view of the interior of the tower. The side arches are not stilted, b but their crowns remain far below the diagonal ribs. From the eight crowns of the side arches here extend inclined ridges to the keystone, so that the entire vault exhibits the plan given in the right half of Fig. 65.

Star and Net Vaults.

Diminution of the compartments.

The design of the octapartite vault carries with it a reduction of the areas of the compartments, since instead of four great compartments are eight smaller ones. But a diminution of the compartments is there attained only by increasing the number of supports; it can be done without this by the insertion of new ribs, and this then leads to various richer forms, among which are particularly prominent the star and the net vaults.

The endeavor to reduce the size of the compartments must be regarded as a natural result of the Gothic principle once introduced. When men opposed the ribs as supporting members to t the compartments as the light supported filling surfaces, it

was a next step to multiply the bearing ribs, so as to more c conveniently vault the filling surfaces and to make the mass lighter. Enjoyment of the pleasing arrangement of the lines aided in ever making the pattern richer, until at the close of the middle ages it fell into capricious degenerations.

Therefore the increase in the ribs is to be regarded ar a previously indicated course of development, and thus different causes have contributed to stimulate it.

In the plan given in Fig. 66 with rectangular bays in the m middle aisle came into use the choir ending mentioned in Fig. 64 with a hexapartite vault. This shows that the compartment d c e is larger than any adjacent one, so that there results a not entirely satisfactory appearance, the vaulting courses of this compartment extend awkwardly, and if they are swelled, a greater rise of the segmental arch forming the swelling is necessary. This extra height may become inconvenient for the beams that extend over the vault. Moreover too large a compartment makes necessary an increase of the thickness of the wall. And this leads to a farther division, as by the two half groin ribs d c′ and e c′, with the ridge rib c′c resisting the side thrust at the crown.

The same condition is repeated in the middle square. If all four compartments are divided here in the same manner, these will pass to the plan of the star vault, as found over the middle square of the cathedral of Beauvais and many others.

The subdivision of the compartments by an increased number of ribs may however be demanded by other considerations. For example, let Fig. 67 be the plan of a tower vault at the centre of which must remain a circular opening, to be able to hoist the bells or some building materials.for repairs. This opening is enclosed by a horizontal ring supported by the ribs. If the ring consists of but four pieces a b, b c, etc., the groin ribs suffice to support it, but if the opening is so large that the requires more pieces, say eight, then it is advisable to increase correspondingly the number of points of support. This can be done by the rising vault with ridge ribs k a, etc., or otherwise by the insertion of the ribs h b, h e, will attain the purpose.

Star vaults.

The preceding and many other conditions lead to the division

by ribs in the most diverse ways. Star vaults occupy the most prominent place of all. The clearest and simplest form of these is shown by the crossing bay in Fig. 66. It originated by inserting in each triangular compartment of an ordinary cross vault three ribs bisecting its angles, which unite at a middle point. When this division is applied to the richer kinds of cross vaults, there are produced correspondingly richer forms. The octagonal vault thus gives the form represented in Fig. 68, which is placed for comparisson beside the star form resulting from the octagonal vault. They only differ in that the first has eight points of support placed in a square, but in the latter they are arranged in an octagon. Rooms with a regular polygonal plan lead to particularly beautiful star forms, which a are transferred in corresponding form to the polygonal choir ending. Over oblong bays of vaults may likewise be placed star vaults, as over squares they acquire only a displaced form, that indeed in reality by the curvature of the arches has a far less pleasing effect, than in the plan.

Naturally over entirely irregular plans may also the cross vault be transformed into a star vault.

A somewhat different shape is shown by the star vault that results from the cross vault with projecting ridge ribs (Fig. 70). The crown or ridge ribs, whose origin is to be referred to the technics of vaulting, is found very early in Norman and English vaults, but already occurred in the Romanesque period in Germany, as proved by the churches at Osnabruck and Münster. They connect the crowns of the side arches with the keystone, and as a rule rise toward the latter and are formed as segmental arches. If the ridge rib already divides the surfaces of the vault, this also favors in a high degree a further extension of the division. Fig. 71 shows an addition of ribs that support the ridge ribs at the middle, very desirable with its generally flat form. There results in this way a very widely distributed star form, for example found in employment for the crossing of the cathedral of Amiens. Likewise frequently occurs the arrangement in Fig. 72, that among others is shown by the cathedral at Schwerin and the churches at Köslin (Fig. 74, but more rare is the form taken by the abbey church at Westminster in London (Fig. 73).

The adjunction of the choir polygon to the rectangular bay

of the vault still leads to other varying divisions, for example as shown by Fig. 75. Here the choir ribs a C and d C meet e C and f C going in the same direction. If then for the ribs b C and c C are to be provided a corresponding resistance, there result the partial ribs C g and C h, that extend from the crown of the choir vault to the side of the cross rib e f, and therefore not to bend this sidewise, thus appear to require the arrangement of the ribs g i and h i, thereby continuing t the same movement through the entire width of the bay. We say appear intentionally, for a very compulsory structural need does not exist, the thrust of the ribs e C and f C and of the adjacent compartments bordered by them can suffice to resist that of the polygonal vault; thus there generally results no further advantage from the entire arrangement than the single reduction of the compartments, and we gradually pass to the point, where the ornamental construction passes into structural decoration. We shall not express blame by this, but it is undesirable, that the richer forms like those represented in Figs. 76, 77 and 78, are rather due to an endeavor for greater magnificence, than owe their origin to a structural motive.

Two of these examples already exhibit an interruption of the diagonal ribs, thereby forming a transition to the class of v vaults now to be described. Generally the richness of these forms in plan is capable of the greatest enhancement and diversi

Net vaults.

Yet more varied than the star forms are the shapes comprised under the name of net vaults. As star vaults are designated all plans of vaults previously considered, so far as they are based on the simple cross vault. In them the square or rectangular bay is divided by groin ribs, and each compartment thus formed was subdivided into a larger or smaller number of subordinate parts. For example, the plan of a simple star vault thus resulted, in that each triangular vault included by the diagonal r ribs was subordinated like a triangular vault first in the richer forms, thus developed like Figs. 77 and 78, the diagonal r ribs appear as interrupted, or rather separated into two ribs meeting at the same angles, i.e., the direction of the principal force is resolved into two components. The further execution of this system, thus the substitution of the resulting by the generating, of the diagonal by the components, and conver-

conversely, now forms the theme, which is to be varied in the compound piers, and that with the principle of an increase in the intersections makes possible these richer forms. Thus in the plan of the simple star vault may the groin ribs be conceived to be replaced by other ribs and therefore be omitted, thus passing to the plan given in Fig. 79, that again represents a simplification of the star vault. It exhibits the net vault in the simplest form.

It would be incorrect to desire to refer the origin of the net vault to only a capricious enrichment of the former. W What justifiable ground for this can be deduced is shown by the consideration of an elongated bay of a vault. In this there result angles of very different sizes at the beginning of the ribs as in Fig. 80. But from these besides the very ugly appearance results the fault that the members intersect each other very irregularly, and that on account of the different forms of the various compartments, the ribs easily receive a greater thrust from one side than from the other. Equal sizes of angles in the spandrel are for these reasons advantages for every ribbed vault. But if on a rectangular bay the ribs are drawn in the direction of the line bisecting the angle and not in the diagonal, there results the net vault represented in Fig. 81 instead of the simple cross vault. This arrangement of the ribs makes possible at the same time a skilful adjunction to the choir vault, that is frequently executed in the manner sketched --- for example in the church at Notteln in Westphalia

What free forms can be assumed by the net vaults are shown by the examples represented in Figs. 82 and 83 from the church S. Maria at Danzig and the cathedral at Kaschau. Here are found engaging general patterns, in the place of which frequently appears a confused web of lines in the late period.

All these shapes exhibit only an interruption of the diagonal arches, and the cross arches being retained. If the latter are omitted, then the character of the net vault appears more decidedly.

We shall now examine the condition of the cross arches, effected by the division in the various bays. In the works of the earlier period their importance was really structural, among others by the strong stilting or required by the arrangement of the flying buttresses. (As will later be shown and treated

in that section). Accordingly they received a greater thickness and bolder profile than the groin ribs. But for the erection of the vault itself, this enlargement was generally unnecessary, and therefore it was omitted already in the 13 th century in many cases. The cross ribs then received forms similar in shape and size to the groin ribs, and thus there resulted a condition not essentially differing from the cross ribs but a more perfected expression. But thereby was it only accidental, that they retained their direction, and according to the principle already applied to the groin arches, it could be replaced by the s sides of a lozeng.. Thereby men advanced to the plan of the elongated net vault (Figs. 84, 85, 86).

Net vaults of tunnel form.

The most characteristic indication of the latter is therefore to be sought in this, that the groin ribs vanish, that thus the subdivision in bays disappears, and the ribs now possessing the same function for the vault rise from piers or from s separate springings at the wall, but without emphasizing these anywhere in the entire scheme, weave the most varied lines over the area to be vaulted.

In a very decided way this character is expressed in the manner reproduced in Fig. 86 at many places, for example in the choir at Freiburg-i-B, in the Catholic church in Marburg, etc., with certain variations concerning the number of divisions, a and the plan of the springings of the ribs repeated in the plan of the vault, from which with the rise of the before mentioned principles of formation can be developed the most varied forms.

In elevation these vaults mostly have the shape like tunnel vaults, only that along the wall are triangular compartments cut in the form of segmental compartments (hatched in Figs. 84 and 85).

The entire surface of the vault is covered with lozenge panels, that are termed meshes. According to the number of panels placed in the width of the vault are distinguished net vaults of one, two, three meshes, etc. If the distance between the p points of support corresponds to only one mesh (left half of Fig. 84), the ribs for a regularly coursed network, intersected by the side triangles a b m, etc. as segmental compartments On the other hand if the distance between points of support ar

greater, for example equal to two such lengths, as in the right half of the same Figure, then also is consequently increased the size of the segmental compartment c d h. The parts o v and p v of the ribs can be continued over the segmental compartments, and then form a a break at o and p, to rise to the crown V. T they are generally omitted as on the left half of Fig. 85. As a rule men even went further, when they also omitted the parts i s and t k, but added therefor the transverse rib pieces b k and c l, etc. (Right half of Fig). Thus resulted an arrangement, which occurs with special frequency, and which is represented in plan and elevation in Fig. 86.

In this vault nearly all points of the ribs, that in the same longitudinal section fall on a horizontal, lie exactly the same as in the tunnel vault. Yet there remains the principal difference between this and the tunnel vault consists in, first the compartments are vaulted on ribs and thus are supported by them, second that compartments may have a special swelling varying from the surface of the tunnel vault, and third that the form of elevation is not determined for the cross rib but for the rib extending obliquely.

For edtermining the form of the elevation is selected a rib as a long continuous rib, giving it the desired form as a round, pointed or depressed arch. This arch is termed the principal arch, and all other parts of ribs have the same form. On this further see the following chapter (p. 62 et seq.).

If the principal arch is a semicircle, the cross section of the vault will be a vertical half ellipse. Accordingly that generally emphasized agreement with the tunnel vault is only based on an external and accidental similarity, that entirely disappears when the plan of the direction of the ribs experienthe least change according to the principles mentioned above.

For example in the plan of Fig. 87 the oblique ribs are broken at places, and are rpplaced by transversely directed parts of ribs. Since no through ribs exist, care is taken in such cases to assume the principal rib for a broken course of the rib, i.e., as shown in Fig. 87a, the plan lengths of the rib course c e a″d are successively laid off, and the principal arch is struck over their added lengths, this arch being a quadrant, for example verticals erected at the points e and a″ determine at E and A the heights of the intersections, while

the rib pieces c E, E A and A″D exhibit the actual form and l length of the corresponding rib pieces. Eny other piece of the rib, for example d is found in the same way by laying off the plan length at the corresponding place on the principal arch. Verticals erected at the ends here again cut a piece D from the principal arch, which gives the actual form of the rib piece. If in this manner the vault is determined by a principal arch on the broken rib course, its form differs in both longitudinal and cross section as shown by Fig. 87b.

On the advantages and defects of such structures according to a principal arch, see the following Chapter, p. 66.

From the plans of Figs. 86 and 87 can be developed all possible forms by simplifying as well as by richer combinations, by changing the relations and locating piers, directions of ribs, by continued application of the system of revolving diagontals into sides explained above, conversely sides with the diagonals.

Thus in Fig. 86 all meshes along the sides may be reduced or increased at pleasure. From Fig. 87 may be derived forms like Figs. 88 and 89. The derivation of evey nev forms of network can in general be carried to infinity.

Staggered springing points.

In the two plans last given in Figs. 88 and 89 the springing points of the vault do not lie opposite each other, but are staggered. Such forms are already found in many Romanesque works and they increase in the Gothic period.

An arrangement based on the system of the cross vault is found on the side aisles of the church of barefoot friars in Erurt belonging to the 13 th century, on a plan corresponding to Fig. 90. The aisle piers stand at a and b, and are connected by the side arches. Above the crown of the last lie the two diagonal arches c d and d e as quadrants, thus determining t the heights of the points f, also the form of the diagonal arches a g and b g, whose halves correspond to the parts e f and c f, which are pointed arches. From g then extends the cross arch g d as half a stilted pointed arch toward the side arch. A perspective view of this with the entire arrangement. of the section connected with the arrangement is shown by Fig. 90a.

Similar conditions of the location of the piers are found

in the cross church at Breslau from the 14 th century and in S. Stephen in Vienna from the 15 th century. In the former the solution is effected by the division of the vault of the side a aisle into three triangular bays as in Fig. 91, and in the latter by the peculiar treatment of the net vault. With particular ease is the latter vault adapted to the solution is such cases, as in general to all irregularities. If we return to Fig. 87, then a location of the piers corresponding to Fig. 90 would be easily combined with the scheme of the first Fig., if g g be assumed ar the distance between piers at the outer wall and c e as half the distance between the detached piers.

As in all these cases to each inner pier corresponds an outer one, and only the number of the latter is doubled, but also with the same number the opposite placing may be omitted, or the row of the points of support in the different rows may be no longer 1 to 2 but even 2 to 3 or as otherwise desired.

Examples of the placing of points of support in equal numbers have been developed in Figs. 88 and 89. In the last case the support always lies on one side of the middle of the arch opposite the other row, in the first case is found a less regular condition.

The ratio of the supports of 2 to 3 occurs in the east wing of the cloister of the cathedral of Meissen, whose ground plan is shown in Fig. 92.

The crowns here are a b c d e f, the generating arches are g b, m c, m a, as well as all extending from the point n. The point k lies just as far from the crown b as the point l from the crown a. At the southeast angle as seen by our Fig., is r represented a transition to a simplified plan.

Forms of the late period.

In the late period were added to the ribs various enrichments they were set doubled and opposite, furnished with perforated tracery. The wall spandrel rising vertically above the ribs g gave the first impulse to these forms.

Already in the Romanesque period the irregular intersection of vault surfaces led to such solutions. For example if the rectangular bay a b c d in Fig. 93 is spanned by a semicircle at the long side, on the short side by a stilted semicircle, there will rise in elevation over the haunch of the cross arch the triangular wall m n o. Raised or stilted arches usually

lead easily to this form, that is especially often found on p polygonal choir endings, also generally with hexapartite vaults. (Fig. 62). The later rich net vaults afford still more opportunity for such forms. Thus it occurs that in the net vauld represented in Fig. 86a, only the ribs extend down to the low support a; on their backs are carried up a high vertical wall, a against which the surfaces of the compartments are first placed far above at the height b c. This then forms over each rib a vertical piece a b c of wall, as shown in section and plan in Fig. 86b. It is next to perforate this bit of wall, resolving it into tracery.

Perforated spandrels over ribs.

A very rich example of such an arrangement of a vault is shown by the cloister of S. Stephen in Mayence, a sketch of this southeast angle being given in Fig. 94. Since the angle projecs into the room, it combines a great number of ribs. The intersection of lower and upper ribs must naturally be wrought in one block, that Figa 95 represents in perspective. Also the function of the upper rib with the vertical descending shaft consists of one piece, which requires tolerably large dimensions, as shown by the plan in Fig. 95 e. The cross section of a rib assumed in Fig. 95 a shows that the mass a b c must be continued, that is favored by the development of a of a cusp at this place. If the cusp is repeated on the cut stone lying beneath this, then results a treatment of the perforation like tracery. In larger proportions the tracery will naturally be enriched, and can be utilized in the opposed stresses in the upper and lower ribs.

The system on which the entire form is based, the perforation of the wall erected on the rib, meanwhile occurs on many earlier works, even if in varied execution. We mean the ceilings of stone slabs, for example that in the tower of freiberg cathedral occur over the lower hall in the octagonal tower, and similarly over the chapel in the northern wing of the cloister of Magdeburg cathedral, and which thereby alone differs from an actual vault, that the courses turned in flat arches in the latter between the ribs are here replaced by stone slabs, which then join over the back of the rib. Here in order to offer this support, the latter must be made horizontal, and this leveling is effected either by a system of mullions and arches as

in Freiburg, and shown in perspective in Fig. 96, or by a direct insertion of circles and other forms of tracery in the spandrels between the back of the arch and the horizontal above as in Magdeburg. The sole difference between the construction in Figs. 95 and 96 lies in this, that the rib c in the first Fig. forms an arch, but a horizontal in this. Also while the first only requires support by an abutment, the latter needs a continuous support, which again must be borne by the rib c". Therefore if as in Fig. 96 this support is made by posts or little columns, then must the seats for these be wrought on t the cut stone forming the rib e", and at the same time must t these pieces be long enough for each to receive at least one mullion, since with unequal loading the different pieces that are less or not at all loadedmust be forced upward. More exact conclusions concerning the loading of the ribs easily give the easily consthucted line of support for this case. Therefore e each single piece of the rib must have about the form shown in Fig. 96a. Indeed in Freiburg the execution is less careful, for the seat is only cut for about half the width of the mullion, the other half being sunk in the back of the rib, whereby stone material is economized for the rib.

The loading of the rib forms an essential advantage in the construction of Fig. 96, when thereby the rib is ensured against slipping sidewise. The lack of this safety in Fig. 94 compels the use of artificial means such as iron cramps or dowels, shown by the before mentioned cloister of Mayence, and forms a weakness in this otherwise entirely structural arrangement. But the structural character is entirely denied in certain forms of ribs in late Gothis, whose origin can be sought only in the pleasure in the varied effect of such perforations. In many places and among others in S. Leonard in Frankfort are found two ribs with different radii under each other. This arrangement can be justified structurally, if the load of the compartment is taken on the upper rib, and the lower two cross points are stressed. But the lower rib is often an entirely useless accessory, that sometimes can retain its position only by an iron dowel. Fig. 97 shows this indeed rich but entirely capricious design.

Doubled system of ribs.

Striving for rich forms was expressed more and more in the

designs of double systems of ribs likewise belonging to the end of the 15 th century. Only the upper one of these is connected to the compartment, while the lower one starting from the same shaft is entirely separate from the upper and forms its connections after an entirely different scheme, so that the upper edge of the lower rib extends beneath the bottom edge of the upper one. An example of this arrangement is found in the church of the village of Langenstein near Harburg (Fig. 180). The effect of the two systems, of the two forms intersecting each other, is still enhanced by the shadows cast by the free ribs below on the surface of the compartment, and is truly surprising. But not less astonishing is the thoughtful arrangement of the plan, the extremely skilful connection of the development of the square or octagon with that from the triangle or hexagon. In this respect it is not unfruitful to compare the past with the present. There are few mechanics or even architects able to devise an arrangement at this time, to which a plain village mason in Langenstein was equal. And it is not the certainty of execution won by repeated practice, it is in a far higher degree the direct invention, in short the real purpose that makes the fame of the old works.

The vault mentioned first belongs to the late period, it suffers in an enhanced degree from the before mentioned weaknesses particularly in the need of iron cramps for the lower system, and is merely a study than intended for imitation. A still richer example of the same kind is found in S. Willibrod in Oberwesel.

Suspended arches and cusps.

In the late period the lower edges of the arches and vaults frequently are a continuous series of suspended arches. This is the same mode of ornamentation already found far earlier on arches of portals. They were then transferred to the cross arches in the interiors of churches as in the Romanesque church of S. Isidoro at Leon in Spain and later in the church of S. Jacob at Liege, where they are even arranged in two parallel rows. They finally appear on the cross arches and ribs. For the latter they are found either only on the parts next the keystone and are omitted downward, as in the choir of S. Sebald's church in Nuremberg, or are continued on the entire rib from the capital to the keystone, as in the northern side aisle

of the cathedral of Mayence, and in the peculiarly graceful s stairway tower of the house in Rue de Forge in Dijon (Fig. 90; Fig. 99 shows a section of the rib).

Likewise there belongs to the more ornamental forms of ribs what often occurs in connection with the richer plans of star and net vaults, the placing of the cusps on the sides of the ribs, which then extend freely below the surfaces of the compartments, but at the same time require a greater width of the stone for cutting the rib. Such an example is found in one of the chapels of S. Maria im Capitol in Cologne.(Fig. 100). As a rule the profile of the rib is contracted at the top to allow the cusp to rest free (Fig. 100a).

Bent series.

Directly from a continuation of the ribs with cusps results the form of the ribs that make a sort of tracery in plan, that in the beginning occurred in connection with straight ribs, as in the vestibule of S. Maria at Mühlhausen (Fig. 101), while later the entire plan of the vault is so formed. Slightly curved ribs can be justified, as already stated on pa 28, but there is no mention of it in the so-called sinuous ribs of the late Gothic, of which a chapel on the southern side of Strasburg minster gives most decided evidence. The effect of the ribs winding in space like snakes is truly distressing and extremely poor. Fig. 102 shows such an example in plan.

The construction of the elevation of the arch of this curved rib is first done for its chord, thus for the part a b of the arch in Fig. 102 over the chord a b etc. From the elevation arch constructed for the chord a b is therefore then determined the arch of the rib proper in this manner, for example the height of the point d″ equals that of the point e, etc. If in Fig. 102a the arch a d e b is the isometric projection of the arch turned over the chord, then is the arch a″d″e′b″ the actual arch of the piece of the rib, that is formed in the same way from b e etc.

In the same manner then also occurs the practical execution, for the side surfaces of the centering set over the chord a b are made of a piece of wood of corresponding curvature.

The direction of the joints in the compartments can be assumed in various ways. The plan of the vault generally decides the choice. This decision may either be a separate one for each c

compartment, so that the joints for the different compartments meet at oblique angles on the backs of the ribs as in Fig. 103, or the joints pass in straight lines over the backs of the ribs and intersect at an oblique angle on the next rib as given in Fig. 100. Finally they may pass in a straight line over all r ribs and intersect on the middle line of the compartment just as on the ridge line of the cross vault. The last arrangement is reproduced in Fig. 326 for a vault without ribs.(More on the construction of the compartments follows in a special Chapter

5. Form of elevation of the vault according to static and practical respects.

In the preceding Chapter the richer forms of vaults are chiefly treated according to the form of the plan of their ribs, and now will be collected the most important requirements for form and elevation.

The diversity of forms of the elevation is no less than that of the formsof plan. The principal of Gothic to develop every part of the structure strictly from the actual requirements becomes particularly prominent in vaulting. For two different basal needs Gothic also creates two different vaults. The variable plan of the bay, actual height of the construction, nature of the materials, absolute dimensions of the vaulting, height of openings for light, kind of distribution of the supports of the vaults,--- all these perpetually produce changed c conditions, which afford a welcome tendency to ever new solutions. In this permanent change rest in great part the magical charm of mediaeval works.

It was natural that under similar conditions also similar f forms resulted, which received a commonly recurring stamp, but at first never led to any rigidity. The masons' lodges must first have lent themselves to training in the proper nature of the matter, not to a dead cramming of all formulas; this could not even in the later time be too rigid, as proved by the free exchange of the animated transformation of forms recognizable from decade to dec.de. At the last end of the middle ages the art of the compasses and ruler certainly came once more into honor, and the living art of construction became a dead mechanical form, that passed into the Renaissance period and there ossified without any relation to practical creation, until it only lost itself in its last remains in our days.

Very instructive in this respect is the extensive work of Hoffstadt --- Gothic A B C --- Frankfort in 1840. Based on traditions of the late middle ages and still more on those from the 16 th and 18 th centuries (drawings, masters and writings, drawings, etc.), the author has developed an entore system of geometric rules of construction, that extend to all parts of Gothic structures, as thickness of walls and piers, tracery, arches and vaults, and even to the late Gothic foliage. The geometric relations are mostly developed from the square (ratio of side to diagonal), the equilateral triangle and the circle. However instructive the work, one can assign to it no important value for the understanding of early and m middle Gothic. Some rules for the construction of star and net vaults introduced by Hoffstadt will be described at the close of this Chapter, but it seems first required to consider these vaults from other different points of view.

Treatment of the form of the vault with reference to the equilibrium of forces.

a. Opposed position of intersections.

The vault as a system of beams.

To render easier the idea of the location of alternate dependence of the intersections of a rich ribbed vault, first conceive the components to be omitted and the ribs replaced by straight beams or struts, so arranged that they can transmit only compression and not tension. Meanwhile neglect the weight or loading of those beams, all existing loads being conceived at the joints or intersections, that are to be regarded as movable hinges.

An ordinary cross vault then takes the form of a rectagular pyramid (Fig. 104). For a simple star vault there is added on each side of the preceding pyramid a triangular pyramid (see left side of the Fig.). If the four supporting points A, E, C, D, are fixed and immovable, then the apex S is also a fixed point. Then are all three base points A, E, S, of the little pyramid and its vertex E also fixed. This apex could also on its own part again furnish the fixed support for a ridge rib E F. The entire star vault is thus represented as a fixed and immovable framework of struts.

The little pyramid can be much flatter than it is drawn in the Fig., the apex can be moved back quite close to the basal

area (M E in Fig. 105). As long as an upward movement of the crown S is prevented (see on this pa 43), so long will the permanence of the pyramid be ever assured thereby, only the c compressile stresses in the stone struts will be greater, the flatter this inclination. But now if the apex is moved back y yet farther, so that it falls in the basal area A, E, C, or e even under it, then will the limit of pressure be reached or exceeded, the three struts will fall (since safety from tension was not assumed).

Safe height of crown.

From this follows the first fundamental condition for the durability of the vault; every crown must lie above the plane passing through the basal points of its supporting ribs.

Let the wooden struts now be replaced by the actual stone ribs. Very short ribs could be formed as straight stone beams, just as the English late Gothic actually employed straight ribs of small lengths, that must naturally consist of a single piece. When longer ribs are composed of a greater number of s stones, this forms the natural transition here as in other cases from the stone beam to the arch. The form of the arch will be already decided by the weight of the rib, and still more by the side load of the compartments. By the curved shape of the rib must a second basal condition for the durability of a terminal point be added. In Fig. 106 the terminal point E may indeed be supported by the straight beams A E and B E, but not by the arched ribs over them. These show a deflection between R and S, that would cause the middle stones of the rib to fall. If the crown cannot be hung on an upper separate bearing arch or a similar expedient, then may be given to the back as much size as required by the safe transmission of the compression, or a longer piece v w is made of a single stone, that will not break under the forces acting in it. Under such conditions are actually found examples of somewhat sunken crowns. (For example in the rich net vaults of the cloister at Aix-la-Chapelle.

Avoidance of sunken intersections.

From the preceding follows the second basal condition:- the supporting ribs must not sink greatly at the crown, or special security must be provided.

Supporting the crown by ribs.

Further results the third condition, that each crown must be supported by at least three ribs, so directed that every vertical plane passed through the crown on both sides has at least one rib.

As a limiting case will be the supporting of the terminal point be only two ribs lying in a plane, and the latter would stand upright like two rafters opposing each other, so long as no transverse side force acts on them. But this would always require sidewise bracing, that could be required from other ribs or from the set surfaces of the compartments.

Very frequently were then three ribs meeting at the crown, indeed four, six, eight and even more. Among them must be at least three that satisfy the previous conditions; Strictly taken in general only with the existence of three supporting ribs can the distribution of the compression to each be accurately determined, for with a greater number the consthuction is no longer statically determinate, and there could occur here by accidents in execution a distribution of the compression calculated with great difficulty (just as for a table with three legs, each always bears its part, while for four or more legs this cannot be assumed). In the execution of the vault the ductility of the mortar takes a great part, to first produce an independent suitable distribution of the forces. F For a rectangular vault for each may one assume with great safety that each of the four ribs properly transmits its part of the force, and then there must occur a substantial movement in the position of the abutment or in the loading.

When more than three ribs unite in a crown, they cannot all support it, or besides the required supporting ribs may also occur loading ribs. (See D S in Fig. 107 and F E in Fig. 104). A rib must act as a load if its lower end lies above a plane m n o (Fig. 107), which passes through the terminal point S parallel to the ground plane A B C of the supporting ribs.

Still more common than such ribs, that support with one end and load by the other, are such that have to support a crown with one end, or more correctly have to keep two points apart. Such bracing ribs especially occur on net vaults, which often exhibit entire series of them. One must regard them as a supporting rib for each of the two crowns, for example, o s, p s, etc., in the net vault of Fig. 109 a. In the star vault of Fig.

108, on the contrary n s must be considered as loading the point s and as a rib supporting the point n.

The beams of a framework corresponding to the star or net vault generally receive compression for a vertical loading of the intersections. But in special cases may also occur tension in one beam (or rib), as shown by the following consideration.

In Fig. 105 (scheme of the ordinary star vault) the point E may lie very near above its ground area A E S and be strongly loaded by G. This produces compression in all three supporting ribs, of which the rib E S seeks to raise the crown S, in case it does not have in its load P a sufficient counterpoise, A r rise of the crown would produce tension in the ribs A S etc.

4. Inadmissability of tension in the ribs.

Since an ordinary masonry rib can bear no tension, such a vault would not be durable. Therefore must be established the following fourth basal condition:- The form and loading of a vault must be of such a kind, that no rib needs to receive tension in its length.

Location of intersections in star and net vaults.

The preceding four conditions must always be satisfied, if the mutual positions of the intersections shall be ensured. For one part of the vault they alone suffice, not at all for others. For this may at once be seen that a decisive indication may be derived for the simple cross vault on one hand and for the net vault on the other.

For a star vault with intersections all are supported by immovably fixed points (Figs. 108 a, b), that makes possible every arrangement of the intersections, which corresponds to the established four conditions, as a structural vault that can be erected. However these conditions still allow great freedom, and thus in Fig. 108 the intersection m may be dropped within the permitted limits, and on the other hand may follow a raising of the point n. Such a shape forms an unchangeable equilibrium of the intersections with each other, that also continues when the load changes.(For a changed form or a different loading there naturally change correspondingly the magnitude of the forces in the different ribs, whose dimensions and forms must be suited to the loads). The advaytages of these star forms thus consist in this, that they permit a tolerably free arrangement of the intersections, and that the entire

system itself cannot be displaced or is stiff for a changed l loading of the intersections.

It is different for the net vault of Figs. 109a,b(likewise for Figs. 82, 83 and many others). Since the diagonal arches are broken, the crown S is not firmly supported by them, and consequently it cannot be regarded ar an immovable support for the other ribs s o, s m, etc. The entire system of ribs finds itself in a condition of labile equilibrium, if it is conceived as a system of beams with hinged joints. The intersections are not fixed but allow themselves to be moved against each o other. A condition of rest for the system is only possible for an entirely determinate mode of loading belonging to this position. If the distribution of the load changes in the least, all beams would lose their position at rest and fall together. Each new load requires a different position of the beam for its safe reception. For example, if the crown S is more heavily loaded, then must it first be raised higher; generally a heavier load requires an elevation, or the removal of a load the lowering of the intersection concerned, so that equilibrium may occur. It is evident, that for such labile net forms the heights of the intersections are not entirely free; if the supporting points and also the rise of the arch are given, the further heights of the different intersections will be fixed by the loading. As shown, to this is opposed the great freedom in the form of the fixed star vault, which particularly in the earlier time of its use was frequently utilized; but the more in the later Gothic men passed to the variable net forms with meshes, the more must they choose uniformly curved forms of vaults, surfaces like spheres or cylinders.

Distinction between star and net vaults.

We believe that the distinction between star and net vaults is best made known, as that by a star form is to be understood a fixed, and on the contrary by the net form is a labile connected system of ribs. (In this sense will both expressions be employed in the following).

With an unchangeable or stiff system of struts (star vault) it occurs, that with m intersections and n supporting points, there are required to be at least 3m + n - 3 arches (the enclosing side arches are not here included as arches).

In reality net vaults with a fixed mass are naturally long

because not so labile as an assumed theoretic and unreal system of struts. The bodily extent of the ribs, the stiffness of the intersections and the bracing by the compartments make the vaults immovable to a certain degree. For no too great changes in the loading the corresponding lines of support will not greatly differ from each other, so that they all find a safe place in the interior of the material ribs. If consequently the net vault is correctly constructed in form and thickness, it is not so much inferior to the durability of the star vault, but it always in contrast to that shows the restraint of less freedom in the location of the heights of the separate end point

If all is once briefly included, it appears that the first established four conditions suffice to prove a safe location of the intersections for the firmly supported star forms, but that they do not suffice for the net system of meshes. For this must be applied the generally valid requirement (also including those conditions), that the arrangement of every ribbed vault must correspond in position to equilibrium resulting from the loading.

Equilibrium polygon and equilibrium network.

The theoretical obtaining of the equilibrium location for the intersection of such a vault will mostly be not very simple. Its form will be best be represented, if beneath the vault is conceived a suspended network, whose intersections are loaded exactly like those of the vault above. This net will assume a form that gives a faithful reflection of a system of struts corresponding to the vault above it. The difference between a net of struts and the equilibrium network is this, that in the former all struts are in compression, in the latter all strings are in equal tension, and further the network of struts are in labile equilibrium, but the equilibrium net is in hanging equilibrium, i.e., the former strives to leave its position of equilibrium, and the latter always to return to it. If the loading of the equilibrium network is changed, it passes of itself into another position corresponding to this loading. The last must be given to the network of struts, so that it may stand under the new load. When in the network of struts for a loading an unexpected tension arises anywhere, this is also immediately to be recognized in the equilibrium network. There the intersections will move toward each other and the string lying bet-

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between them will slacken.

Such an equilibrium network is for the vault the same as an equilibrium polygon for an arch, which is loaded exactly like the arch itself, thus the theoretically correct arch line will appear in the reflection. If the loads are continually added, the curve will appear; but since the loads are suspended at certain points, there results a broken line as the equilibrium polygon. The theoretically correct form of arch corresponding to it will be termed the line of support or line of pressures in the arch. Graphic statics constructs this line simply by m manifold applications of the parallellogram of forces (Müller-Breslau, Elements of Graphic Statics, and others). By this is found not only the directions but also the magnitudes of the forces. An extension of graphic statics to network forms in space is not so very simple for most cases, since its constructions can only be executed in the plane. For example, if one has to do with three forces in space acting at a point, two m must be combined in a resultant, which lies in a plane with t the third.

For special cases in practice it can be actually recommended to make network models with cords or strings (perhaps at 1/10 full size), which is not so extremely difficult, as experiments of the author have shown. If only the determination of the intersections is concerned, then may one be able to properly combine the loads found in the surroundings in the proper manner. The string extended between the points will then appear as a straight line.

If it is desired to obtain in this way also the theoretically most nearly correct curvature of the ribs (which will be treated below), then is the equilibrium polygon corresponding to e each rib is to be divided into a suitable number of separate parts, and to each part is given a force existing in it, computed from the weight of the rib, the thrust and weight of the part of the compartment added, as well as any extra load. In this way may be obtained the theoretically correct form of the rib. If a variable load is to be assumed, they would also the loading of the model be correspondingly changed and its thrusts be observed. All positions of the strings resulting thus must naturally find place within the later body of the rib with sufficient safety.

Net vault with close meshes.

A sound structural feeling in the middle ages, at times made more acute by bad experiences, permitted the correct form, itself always to be found for the richest ribbed vaults. When the network of the ribs was tolerably close, and the loading was not too irregularly distributed, then the skeleton of a net vault assumed a quite regularly curved general form, that was the more uniform, the smaller its meshes. For central bays mostly result a spherical form, for long rooms usually tunnel shapes. Very close networks according to their structural form may be boldly treated as simple vaulted surfaces, but it is not fully stated, that in them one must return absolutely to the accurate sphere or semicircular cylinder of the Romans. Other heights of crowns produce other forms, and further those Roman forms require a diminution in the thickness of the vault, since it agrees little with the theoretic form of equilibrium. On t the latter see further below (p. 53 et seq.).

Between the original vault ribs and the later system of meshes is to be recognized a notable difference. Those were strongly loaded supporting arches, that as a firm framework divided the entire surface of the vault into separate compartments' t the latter finally extend as a network beneath a uniformly curved surface, the compartments often les bearing than stiffening, sometimes, whereby is always obtained also a light vault, a l light framework and an esthetic subdivision.

b. Distribution and compression in the compartments.

The preceding treated the general form of the vault, particularly of the reciprocal position of the terminal points. The ribs are but incidentally mentioned and the compartments extending between them are not even mentioned. In a great part of the system of vaulting --- the only cross and star forms --- could one arrange freely within the limits established by the conditions and location of the terminal points. But the more this freedom is used, the closer attention must be paid to a correct form of the ribs and compartments.

To obtain in a strictly scientific way the forces, that may occur in the compartments of a thousand forms, would be extremely difficult, and yet would lead only to conditionally solvable problems in statics. This would be of little use to the practical architect, for whom it is important to obtain a gen-

general view of the effects of the forces, and to take into account in the simplest yet sufficient way his works. To this first belongs a clear idea of the actual conditions; after this is obtained he can easily unravel and traverse such a domain, pathless at sight, as the rich Gothic forms of vaults, as it may be attempted in the following.

Influence and position of the courses.

Very common is the false view that the direction of the pressure in the vault depends on the position of the course of masonry in the compartment. This is generally not the case, for the pressure of a tunnel vault against the abutment and for o other like forms, it has little importance whether the courses are horizontal or diagonal. The position of the courses has its great importance in the erection of the vault and later considerably lessens (although it may always play a certain part in possible failures, at least if the angle between the direction of the pressure anf the course is too acute. See further under compartment masonry). In Early Christian, Romanesque and even Gothic times is accordingly observed a varied change in the location of the courses.(On the position of the courses with the Byzantines, see the preceding Figs. 12, 13, and on those of Gothic vaults, see the later Figs. 293, 319).

Irregular distribution of the pressures.

The essential factor in the distribution of pressure is not the position of the courses, but the shape of the vault, yet even this is not alone decisive, for various other conditions and even accidents may exert a very important influence.

Few constructions are so generally dependend on accidents as vaults. Some may be enumerated here. The stresses in vaults are affected by:- 1, incorrectly arranged strength of the abutments, that cause a certain yielding of the weak and fixing of the strong points; 2, Varied stresses in the abutmentcaused by external forces, for example the thrusts of adjacent vaults, that exceed those of the vault in question. 3, different settlements of the abutments; 4, mortar of varied mixtures or unequally stiff, employed in a vault; 5, interruptions and varied rapidity in executing the masonry; 6, strong stresses in certain courses, while others are loose in the mortar; 7, more or less great variation of the centering, mode and time of its removal. All such cirmumstances may produce little displacements

or movements, which with the small elasticity of the material used may at once cause a notable alteration in the pressures. If in heavy pressures a separation of some parts of the vault be a crack, then will the transfer of the force be the more influenced.

Influence of the mortar on distribution of pressures.

In all these accidental conditions the mortar plays a certain part, and it may equalize or even increase it, and it has a p particular effect whether the mortar is still soft or has already hardened. In general soft mortar favors a uniform distribution of the pressure following the form of the vault, while after hardening of the mortar, the pressure is chiefly transmitted where it finds greatest resistance.

These phenomena are connected with the plastic and elastic qualities of the materials in question. To understand them, c conceive a tough flowing mass near hardening (mortar, asphalt) slipping down and they supported by a jagged body (Fig. 110). The principal load will rest on the projections a, and by compressions and slides of the mass will be distributed also a s smaller load in the depressions b, but the gaps c will be entirely empty. After this change of form the mass comes to rest and hardens. The more stiff was the body, the more will its e entire pressure be brought on a few projections, and the more flexible or fluid it was, the more will its load also settle in hollows.

Similar procedures occur in a vault. If a rectangle be conceived as covered by a convex tunnel or Bohemian vault, this will exert pressure on the longitudinal sides and the transverse ends. But how this pressure is distributed in both directions after the setting of the mortar cannot be definitely stated, as it partly depends on accidental facts. If the end walls are omitted at D C and E F (Fig. 111),(they perhaps also sink by a settlement of the foundations), then the portion of the vault over them will drop and perhaps the lower part entirely falls, over it being formed oblique cracks, when the vault gradually comes to rest and is only supported by the longitudinal walls. (Fig. 111a). Conversely if for the same vault the end walls are extremely firm (Fig. 111b), while the side walls exist but are too weak, (since entire failure would no longer be possible in the case sketched), then the thin side walls w would settle or yield under the pressure of the vault. Consequently the vault will move until its principal mass is suppor-

supported on the firm end walls. Thus here the ends support, which were previously free. On the side wall falls but a small part of the pressure, just as much as they can receive. If more was given to them than they can bear, then would continue the movement for further lessening the load. Thus the compression and movement would occur until a new condition of rest with a different distribution of the load is found. Naturally the abutments must not be too imperfect, since no condition of rest could occur, but the displacements would continue until destruction.

The more the mortar has set and the better it adheres, the more it allows a strong abutment to appear for a weak one; but the softer it is this is less possible. The change of pressure in consequence of displacements of the abutments in hardened vaults is frequently astonishing in old buildings, and one can see by the cracks that the load of the vault has been transferred entirely to other points. In some circumstances may such a change be useful, but in general it is serviceable to the structureto permanently receive its stresses in the same manner as attributed to it.

But for a favorable universal distribution of pressure first to occur, this is to be secured just by the soft mortar. If a part of the abutment yields somewhat, then it will not be relieved of the load by soft mortar, but it rather moves outward a part of the vault under certain pressures until a state of rest exists. If an important part of the abutment is built so weak, that it generally no longer comes to rest, then a soft vault moves till it falls. It is a peculiarity of soft mortar, that bad constructions may become full of mystery, but which is welcome for correct designs, for which will be attained a pressure acting on each part of the vault, which appertains to it by its form.

What degree of softness is favorable for the mortar can only be decided in each case, for it will be better to avoid too flexible mortar, since it may produce unexpected and strong pressures. It usually suffices if only a very slight degree of ductility exists at the removal of the centering. In freehand masonrw there usually suffices the usual stiff mortar, so that the compartments have a movement corresponding to the ever varying load, so that if a powerful wedging together of

some coušses does not occur, the distribution of the pressure finally follows the form of the vault.

Dependence of the pressure on the form of the vault.

It follows from these considerations, that an architect with a clear conscience will not remove the centering ofhis vault too late in order to utilize the favorable activity if the mortar. In some circumstances a very safe construction may be favored by a longer hardening, since then perhaps the work of t the yielding of bad structural parts may be relieved by others built with abøndant strength. It will be assumed in the following, that there is a correct distribution of the pressure according to the shape of the vault, favored by the plastic qualities of the mortar. Then can generally be established the hypothesis, that in a vaulted comparment each part of it chiefly transmits this pressure to the abutment in the direction, which a rolling ball would take, or in other words, that the pressure always seeks to pass in the steepest direction.

The forms of compartments employed by the middle ages are innumerable, for most of them have no mathematical names. Partly horizontal, ascending and swelled surfaces like cylinders, conic sections and all possible spherical or swelled shapes occur, but with all diversity they may be chiefly classed in two divisions, in those curved in one direction with surfaces like tunnels, and those curved in all directions or swelled surfaces.

Division of compartments into strips.

If according to the preceding hypothesis is assumed the transmission of pressure in the vault, then for the true surfaces is a parallel division in strips (Fig. 112), and for a dome r results a radial division of the surface (Figs. 113, 114). F For swelled surfaces not differing much from the dome of rotation, may be used without great error the same radial division extending from the highest point (vertex). For any portions of such surfaces like the curved triangles m n o and p q r as well as the rectangle t u v w in Fig. 114, the division into strips naturally remains the same. Necessarily such parts of surfaces are first to be completed of their vertices, so that these may proceed the division. If surfaces occur that differ greatly f from both tunnel vaults and domes, for example the ascending forms between the two, then according to the rule of the ball rolling downward results a varied division in strips, as inser-

inserted in the Fig. in this case. But generally sufficient accuracy will be obtained, if as in the examples of Figs. 112 , 113 they are made parallel or radial, or both are combined.

According to these examples it is easy to determine for a c cross vault in what manner the surfaces of the compartments are to be properly divided in strips, thereby finding the mode of distribution of pressure in the different directions. This is shown in several illustrations, that will be understood without further explanation.

1. Cross vault with straight ridge. The surfaces of the wault have a tunnel form and are therefore divided in parallel strips perpendicular to the ridge. As an example is taken a half polygonal choir vault (Figs. 116, 116a), that is pointed, and it is immaterial whether the side arches and compartment surfaces are curved according to the semicircle, pointed arch or any other curve. Each strip of the compartment transfers its part of the load and thrust of the vault to its corresponding rib, so that the piece a b of the rib receives the two hatched strips abutting there. In the same manner the load on the pieces c d and e f of the ribs are indicated by hatching. So that the rib may not bend outward, the thrusts exerted by the strips on both ribs must be perpendicular to the rib, as still mentioned. For vaults with an ascending ridge will the strips take the d direction indicated b: dotted lines on the right side of Fig.116.

2. Cross vaults with swelled compartments (Figs. 117, 118, 119). For each compartment is sought its highest point s and from this are drawn rays on the plan, that divide the surface into triangular strips. On a piece v w of a rib (Fig. 117) comes the weight and thrust of the hatched triangle. In Fig. 117 the vertices lie at about the middle of the compartment surfaces, and the pressure is therefore distributed in about equal parts on the ribs and side arches. If the vertex of the compartment is placed close to the keystone (Fig. 118, left), the side arch receives the greatest pressure, and conversely the ribs receive the greatest portion if the vertex falls near the side arch (Fig. 118, right). The compartment may even rise so much at one side that the vertex no longer lies in the triangular compartment but must be placed outside it. In the left triangle of Fig. 119 the side arch receives only a vertical load from the strip, the ribs will not be loaded except

by the never failing horizontal thrust and they bear rather a force directed upward. Conversely in the triangular compartment lying at the right the ribs are strongly loaded, while t the side arch receives an upward pressure.

In this way it is possible by the choice of the form of compartment to place the thrust of the vault on one or the other arch, which has great importance for the erection of such vaults. It is always important to see that the ribs are pressed as equally as possible on both sides, which is most perfectly attained, when the vertices of the adjoining compartments lie symmetrically with the rib. The point s is to be sought in the plan about sidewise from the middle point of the ridge arch.

3. Cross vault with sharp swelled ridge of compartment (Fig. 120). The vault is produced when from the pointed side arch extends the curved ridges f m and g m to the middle, against which the surfaces of the compartments intersect like a roof. Each of the compartment halves is to be regarded as a triangle cut from a surface like a sphere (p o in Fig. 114). The probable vertex s must be extended and the rays drawn from it are shown in the Figure.

4. Star vaults. Here result quite corresponding changes as before, some of which are represented in Fig. 121. According to the location of the vertex may one also here load one or t the other rib or finally also the side arch. An equal thrust from both sides of the ribs is also naturally to be striven for here.

5. Net vaults. For the preceding kinds of vaults each separate part of a compartment can be swelled in the most diverse ways (see left sides of Figs. 122, 123); or as mentioned in other places, there can be assumed for the entire vault a common compartment surface. In the last case the pressure is directly transferred from the surface of one compartment to that of another without the ribs having any special importance. The division of the surface of long net vaults would be into parallel strips as for the tunnel vault (Fig. 123, right); central net vaults conversely would have a radial division (Fig. 122, right); from the middle point s, which extends over the compartments with the single exception of the outer triangles, that ordinarily rise toward the side arches (vertices s_2, s_3 Fig. 122).

c. Correct form of the compartments.

The division of the compartments into seperate strips, which then are arranged according to the shape of the compartments and not in the direction of the courses of stone was very simple to execute, but it now concerns the fixing of a proper curvature of such a compartment strip,and the pressure exerted by it on the rib separating it. Men seek to make the thickness of the vault and compartment as small as possible, and this generally is 10 to 15 cm, but can be reduced still further. According to the usual assumption that the middle line of pressure lies in the middle third of the thickness of the vault, there remains no great play space, i.e., in other words, if we desire to turn this compartment, we must adhere accurately to the theoretically found line of pressure in the curvature of the vault; this is very particullarly true for the compartments in tunnel form. A parallel strip cut from the tunnel compartment is to be treated exactly like a quite ordinary masonry arch, and the line of support is found for it exactly as for the latter.

Obtaining the line of support.

The arch or the strip of the compartment is to be divided into any number of equal parts --- for example 11---; Its weight is calculated for each part, which acts at its centre of gravity vertically according to the scale of lines 1 to 11 in Fig. 124. In a separate force polygon of Fig. 124a are laid off the computed weights on a vertical line at an assumed scale, for example here 20 kil. = 1 mm. This produces the line A B representing the total weight of the arch. If in this case the arch has a symmetrical form and loading, then is drawn a horizontal through the middle point C of A B, on which is to be laid off the horizontal force H existing in the arch. Since H is not to be accurately found beforehand (?), to it is first given an assumed length C P. From the pole P at the end are drawn rays connecting it with the divisions of the vertical A B, that are indicated by Roman numerals I to XII. Assuming H to be correctly assumed, these lines represent in the arch the pressures continuing from one part to another in magnitude and direction, from which is very easily constructed the line of pressure, as done below the arch in Fig. 124b. Here a parallel is drawn to each ray I to XII to produce a polygonal series of

lines, whose angles lie on the verticals 1 to 11. A force IV lies in the force polygon between the verticals 3 and 4also lies in the line of pressure between those verticals.

The line of pressure thus found for a provisionally assumed H can be inserted in the arch above (see S R), which shows that in this case the line of pressure is much too flat; if it remains within the arch it must be steeper or more curved. This is obtained by assuming a smaller horizontal thrust H, for there corresponds to a higher arch a smaller, and to a flatter arch a greater thrust. Therefore is assumed in the force polygon a smaller H by moving the pole P to P'. For this pole is made the same construction of the line of support, and if necessary the process is continued, until the most favorable line of support is obtained, i.e., that line of pressure or support which differs the least possible from the middle line of the arch (U S V in the Fig.). It is assumed that in a vault in good condition that pressure is striven for, according to which the most favorable line of support is transmitted, and m generally an arch or vault is held to be durable, so long as a satisfactory line of support is possible in it. Further on the construction of lines of support, see the proper manuals, among others in Müller-Breslau, Elements of Graphic Statics.

The line of pressure U S'V in this case does not conincide with the middle line of the arch, but lies in general within the middle third, at the crown approaching at c the lower limit of this third, but on the contrary at the base reaches the outlimit, also nearing the limits at the sections d e and f g, the outer one in the fisst and the inner in the last. These places are to be considered, for the more that the line of pressure varies from the middle line the more unequally is the pressure distributed over the section concerned. Where the line of pressure passes exactly through the middle as at i k, the arch there receives uniform pressure over its entirek cross section. (For example, if the total compression obtained by the force polygon at a certain place were 1000 kil., but the area of the cross section is 800 q. cm, there is to be taken a pressure everywhere of 1.25 kil per q cm). It is otherwise at the section e d, for the more the line of pressure approaches the outer edge d, the greater becomes the pressure at that edge, while it is comparatively reduced at the inner edge. If the line of pres-

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pressure passes at 1/3 of the width, then is a pressure at the outer edge d twice as great as that on the cross section (thus 2.5 kil instead of 1.25 kil as by the assumption of a total pressure of 1000 kil and 800 q cm of surface), and at the inner edge the pressure is 0. If the line of pressure be moved still farther outward, the pressure at the outer edge is rapidly increased, while tension occurs at the inner edge. If the latter cannot be resisted by the mortar, the joint opens (in fact this can be seen in numerous arches and vaults). If the line of pressure passes entirely outside the arch, then in case the mortar cannot resist the tension, destruction certainly follows. The movement thus occurring is illustrated in the sketch of Fig. 124c, and it is seen as at the dangerous places the so-called joints of breaking alternately open outside and inside. These joints of rupture always open at the side farthest from the line of pressure. It is further recognized how important it is for thin compartments to fit them as closely as possible to the line of pressure, since slight variations are already conceivable.

Line of support for tunnel vaults of uniform thickness.

If the consideration of the line of pressure is so important, then the question is what is its proper form. The vault compartments in question were almost always of uniform thickness, for example built equal to a half brick. But it results for tunnel vaulted arches and vaults of uniform thickness the same fixed line of support, which may be found in the way just described, but it can also be determined analytically (see Hagen, Form and thickness of vaulted arches and domes). In Fig. 125 is reproduced the form of the line of support, somewhat like a parabola, but the lower branches would finally become vertical when prolonged to infinity. An infinite portion of this or of any other line of support can never be vertical below at the support, but will always show a certain inclination outward. If a flat arch is to be erected, then will be employed only the upper portion of the line of support, and for high arches there will be cut a piece from the line of support, which extends down till the necessary ratio of rise to span is reached. (Naturally the form of the line of support can be enlarged or reduced as a similar figure, according as demanded by the absolute size of the vault or by the scale of the drawing made for the

vault to be erected.

Pointed tunnel vaults and compartments.

If the line 6f support be now compared with the forms of arches usual in practice, it appears that a very flat arch shows no important difference from the corresponding portion of that line, and this is also the case for high arches. For comparison the forms of arches are inserted in the Fig. as dotted lines, at the left being the semicircle and the stilted arch, at the right being the pointed arch. It is evident that the two first are very ugly, they vary very much from the line of support, that even by great heaping of the material at the abutments can the line of pressure be brought a little nearer to it. If the line of pressure safely finds its place in the vaults, t then these two forms of arch always give a thick and heavy masonry to the compartment. Incomparably more graceful is a not too slender pointed arch whose preference over the stilted semicircle is strikingly visible, it varies from the theoretically curve a little outward at the bottom and inward above, but everywhere shows only a slight distance from it. When the uniform loading of the compartment is but slightly changed by backing masonry at the lowest spandrel and the addition of a certain load at the vertex, the line of support is changed at once, so that it almost exactly coincides with the pointed arch. No simple arch line struck with the compasses is so near the curve of support as the pointed arch.

We find here the explanation why in the 12 th and 13 th centuries men so readily accepted the pointed arch for the compartments in reducing the thickness of the vault, and also for the side and cross arches. Even the early time of the Normans introduced loaded ridge or crown ribs, which find their practical and also structural reason. What we can obtain theoretically, the middle ages won empirically by its struggles conscious of their aim.

The proportions of the pointed arch differ much in their r rise, and very high and slender arches require special consideration. Of the joints of rupture I, II and III in Fig. 124c, for low pointed arches the lower III comes more in question, and for high arches are rather the upper I and I. In falling a low vault acts as in the sketch 127A; a high one moves as in sketch 127B. The low one is statically favorable if the load

on the crown is small or entirely lacking, but there is behind it a good backing of masonry (Fig. 127C) at least 1/3 of the height, or better is required about 1/2 the height (for the s semicircle is even best more than half). The more slender the arch, so much the more important is the load on the crown, and for an equilateral or 60° pointed arch (circumscribed about an equilateral triangle), this is properly assumed at 1/7 to 1/4 the weight of the arch, and thus is admissable already a heavy keystone or for tunnel vaults a strengthened ridge line.

If the pointed arch is still more slender (Fig. 127D) it can only be erected generally with an uniform reduced thickness of the vault, when the keystone or crown is strongly loaded, by extra masonry if necessary, that is even increased to the weight of the other part of the arch or more. The proper weight of the load on the crown is easily found by experimental construction of the line of support. If executed in proper dimensions, then is in place the strong backing of the spandrel to 1/3 or 1/2 the height, but if the load on the crown is too small, the lower backing must not be too heavy in any case, since otherwise would occur a lifting of the apex of the arch; 1/3 of the weight would certainly be too high in this case, it being assumed to be well bonded.

If it be desired to omit the load on the crown, then for arches of excessive rise are only the following expedients. a, the thickness of the vault is increased so that the line of pressure will certainly find its place, a mode that indeed stands lowest; b, the acute internal angle at the crown is filled (Fig. 127E). Just at this place will the line of pressure fall below the arch most easily without a load on the crown, and if this place be filled by a corresponding closing stone E (or a ridge rib not too narrow), then is much won. Also the addition of a cut stone with long sides will also help (F), it being assumed to be sufficiently strong not to break with the excentric position of the line of pressure. c, a more favorable arch line is chosen, and as such may come in question a pointed arch, whose spandrel below is with a larger, and above with a smaller radius (Figs. 127G, K; also Fig. 49). d, the pointed arch is stilted (Fig. 127H, right). A curvature is thereby produced at top, which agrees better with the line of pressure, and certainly the thrust of the abutment will be greater and applied higher.

The stilted arch was a good and much used expedient in ancient and modern times. The already mentioned compound arch certainly attains the end better, especially if struck with more than two radii? it thereby produces with a great rise a form far more pleasing to the eye than the usual lancet arch with its crown always having a hard effect (Figs. 127J, K).

In every case the easily drawn line of pressure will show which expedient is best.

Correct form of domes and swelled compartments.

Tunnel vaulted compartments require a difficult adherence to a definite form of support;which is much less the case for swelled compartments, as will be stated hereafter. In the tunnel vault the side force acting between two parallel strips can be regarded as = 0, but in spherical surfaces curved in all directions the mutual forces acting between two adjacent meridian strips cannot be neglected, they extend in the direction of a horizontal ring from strip to strip and may either be compression or tension. Whether ring compression or ring tension occurs in the spherical surface depends entirely on its form, and naturally a definite spherical form is possible, where neither compression nor tension occurs in the direction of a ring, and to obtain this form is of great interest. If from such a dome is cut a narrow meridian strip or a slit, no transmission of force can occur between the side surfaces, i.e., such a curved triangle will stand independent, so long as it is held above at the crown and below at the abutment. The form to be given to this strip (and thus to the dome)is very easily found by t the graphic method, when it is considered as an entirely ordinary masonry arch, and its line of pressure is sought for its loading in the usual way. We are here troubled again by the case which occurs with a uniform thickness of the dome or swelled compartment. The form of support then occurring is drawn in Fig. 126, and it is likewise treated analytically by Hagen at the place mentioned. Domes or swelled compartments that have this cross section exhibit neither ring compression nor tension.

It is to be noted, that for the vicinity of the crown the c curve is not entirely correct, for ring compression must always occur there, since the meridian strips end too sharply at the middle to be able to transmit any horizontal thrust.

Hagen recommends in his work;On the form and thickness of

thickness of vaulted arches and domes, Berlin, 1875, p. 59), to form the cross section of the dome directly according to the line established by him and represented in Fig. 126 --- we might not agree to this. The advantage of swelled surfaces consists just in the possibility of a stress in all directions; rejecting the ring compression takes away a great advantage.

On the contrary we might regard as favorable just such spherical surfaces or swelled compartments, which at all heights show a certain ring compression. For such surfaces can never occur ring tendsions even with important variations of loading, for ring compression occurs for the stresses that cannot be received in a meridian direction. Thereby will it be possible to make a swelled compartment very thin even for variations of loading, while a tunnel vault in such cases requires increased thickness to make a safe line of pressure.

From these points of view are to be designated as statically allowable numberless forms of domes, so long as at no point of the meridian or ring compression has exceeded the limit fixed by the strength of the material, and just so long is the dome permanent. To illustrate this are given the forms of cross section I to V in Fig. 126.

I. Section I is to be termed particularly favorable, if the ring compression from the top to bottom is everywhere equally great, and in this example it is as great as the meridian compression increasing from top to bottom, at about a point A.

II. A cone with an angle of 90° at the apex is represented here as a dome, which with uniform thickness has equal ring and meridian compressions at any height. Such a cone indeed exerts at base a greater thrust than the preceding cross section, but otherwise is a good form of dome. Likewise slender c cones or pyramids (roofs of towers) are to be regarded as statically favorable domes.

III. A concave curve within certain limits gives a statically possible dome. But the ring compression below and the thrust against the abutment will be found very great, and indeed the more the flatter is the curve here.

IV. A recurved line (oriental dome) can very well be erected without ring tensions or clamps, in case at no point is it too much rounded externally or anywhere approaches too closely a vertical or horizontal. On the contrary domes curved in bulbous

form below are impossible without special provision against tension, and therefore are absurd as vaults.

V. Most strikingly appear the effects of ring compression in the diagonal section of the pendentive dome (curve V). In spite of the bend inward the dome can be erected as in numberless examples. It is an advantage that the directions a b at the b bend remain rather far from the vertical, which the Byzantines skilfully attained by slight changes in form.

Similar effects result when the dome bears at top a heavy lantern, and a great ring compression exists there, which is less, the more steeply the line of the dome meets the lantern.

For comparison are also given in the Fig. the current vault lines, at the right being the pointed arch, at the left the s simple and the stilted semicircle. It may be perhaps assumed that compression occurs where they lie within Hagen's line, a and that on the contrary in the parts cut out above occurs ring tension. Accordingly the stilted semicircle is very unfavorable, and also disadvantageous is the simple semicircle or hemisphere, where tension is found for fully 3/5 the height, that can be overcome only by a correspondingly high backing or an increased thickness of the lower part of the dome, unless recourse is had to iron rings. A slender pointed arch is much preferable and requires backing only in the lower part.

Generally lines passing into the vertical below are unfavorable, and if they are chosen, there must be assumed the necessary thickening externally to receive compression, the internal lower masonry being a filling mass. The preceding will have sufficiently explained what a great freedom surfaces curved in all directions exhibit in opposition to the tunnel vault; in the preference of the swelled compartment the middle ages consequently shows again in a wonderful way its refined and also practical and statical feeling. In a practical sense the swelled compartment favors freehand vaulting, in a statical sense it permits vaulting of extremely thin compartments in quite capricious forms, that even in strong transfers of the loading or pressures always continue stable.

d. Form of the ribs.

Pressure of compartments on ribs.

The last considerations are true for the form of the compartments of the vault, but almost more important than them is the

pressure against the abutment, that each strip of the compartment exerts on the supporting rib or side arch. If the line of pressure has been found for the strip of the compartment, then at the same time are found its end forces, but one can obtain the latter approximately correct, if the rather tedious construction of the line of pressure does not seem required.

If a strip of the compartment is regarded as a separate whole there usually come in question only three forces, the weight and the two end forces. The weight (G in Fig. 128) is naturally drawn vertically through the centre of gravity and can be calculated, being composed of the weight of the arch and the extra load resting thereon. The direction of the end forces W_1 and W_2 must coincide quite correctly with the directions of t the ends of the arch (or their tangents), since the mostly very thin compartments allow no great play to the compressile f forces lying within them, and further the end forces must pass through an intersection O lying on the line G. Hence the probable location of the forces can be inserted in the drawing with approximate accuracy. If such a position cannot be obtained, this is to be regarded as proof that the compartments have a statically unfavorable form, and therefore must be changed. (Fig. 128a). If the directions of the end forces are assumed, their magnitudes are found by resolving the force G simply by the parallelogram of forces.

Magnitudes and directions of end forces directly depend on the direction of the compartment as hown in Fig. 129. Here a compartment strip extends from the rib A to the rib B, which may give the positions I, II and III, and the end forces belonging to these positions are indicated by the corresponding numbers. It is evident that their directions differ widely, making clear at the same time their differences in magnitude, as assumed in Figs. 129a, b, c, in the resolved forces for the three cases. First the weight G is assumed equal for the three cases and is resolved into the end forces W_1 and W_2, and at t the supporting points these are resolved into horizontal forces (H_1 and H_2) and vertical forces (V_1 and V_2). The first is the side thrust received by the rib and the latter is the vertical load on the rib. In a horizontal direction occur only the forces H_1 and H_2 and therefore these must be in equilibrium and be equal. In a vertical direction the algebraic sum of V1 and

V_2 must equal the load G on the compartment. The great diversity of thrusts and loads on the support appears still strikingly from the figures.

Thus in the case that in a very strongly curved compartment the thrust is small, and the vertical load is divided between the two ribs A and E.

In the second case, i.e., for a moderately curved compartment the thrust is already greater and the vertical force here falls only on the support A (thus V_1 = G and V_2 = 0), since the upper end of the rib is horizontal at the rib E.

In the third case for a very flat compartment, the horizontal thrust is very great. Concerning the pressure on the support there occurs here a peculiarity to be well considered, for the pressure V_2 is directed upward, while V_1 on the lower rib is greater than the load G by V_2 (for $V_1 - V_2 = G$). This case must always occur when one end of an arch or vault is inclined obliquely at top, so that this end cannot exert a downward pressure on the support, as it rather seeks to force the support upward. In the present case the rib E is not loaded by the compartment, but will be supported by it or even be forced upward if not sufficiently heavy to equal by its weight the upward force.

The horizontal force is naturally unaffected at the upper e end of the arch as in general the thrust is less from the direction of the end of the arch then depends on the curvature or the ratio of the rise of the arch. The flatter and heavier the arch the greater will be its thrust, which is always true, the points of support being as we please in relation to each other.

According to Fig. 129, there are wide limits in the choice of the curvature of compartments, for regulating the magnitude of the thrust is required, a fact that has the highest importance to the vault ribs. The latter are so narrow that with a strong sidewise thrust they bend sidewise at once, and therefore the thrusts of both compartments must fall in a direction transverse to the direction of the rib. For example, if a rib A (Fig. 130) is very much pressed sidewise from the left by a great and heavy compartment, it would be very faulty to place at the right a light and strongly curved compartment; that would be forced upward by the excess of the thrust from the other compartment. Rather must the right compartment be very flat and

necessarily loaded extra so as to supply an equal thrust, that naturally also appears at another support C (Fig. 130a). For example such considerations may be necessary for the side compartments of net or star vaults.

If the smaller compartment on the right is too high in the direction of the thrust, and on the other hand is flat enough in any oblique direction, then the excess of thrust will take that direction and thereby be received.

Bending of the ribs.

Thus far the form of the compartments of vaults have been treated, then obtaining the forces exerted by the parts of compartments on the ribs, and it only remains now to deduce from these forces the correct form of the ribs. This would be most simply possible if the ribs were loaded by compartment strips, that on the plan are seen (Fig. 131) to abut on both sides perpendicular to the ribs. Each strip transfers in Fig. 129a, etc. to the rib a horizontal thrust H and a vertical load V. For c correct construction the horizontal thrusts neutralize each o other on both sides, and thus there remain only the vertical forces of both strips that are added to that of the weight of the piece of rib to make its total weight. All pieces of the rib receive in this way their corresponding vertical loads, w with which is constructed the line of support for the rib exactly as shown in Fig. 124, and at the same time is found the correct curvature of the rib, to which the form of hre rib is adapted as far as possible.

That the load of the compartment strip strikes the rib exactly at right angles is seldom to be assumed, as shown in Figs. 116 to 121, but the strips mostly join obliquely like Fig. 132. Each of the two ends of the strips again exert a vertical load on the support and a thrust, the two vertical forces again forming a vertical load V with the weight of the piece of the rib.

But the horizontal thrust H_1 of the end of a rib in Fig. 132 meets the rib obliquely, and it is to be resolved into a force N, perpendicular to the plane of the rib and into a thrust S_1, that lies in the plane of the rib. The force H_1 must be neutralized by the corresponding component from the other end of t the strip, but on the other hand the force S_1 combines with t the corresponding force from the other compartment strip in a common thrust S1, that seeks to move the piece of the rib. Thus

on each piece of the rib acts two forces, the vertical force V and the thrust S. If the force polygon be drawn for one branch of the rib, it appears stepped but otherwise the construction of the line of pressure shows no difference (Fig.133).

Making end of rib secure by backing masonry.

To this line of support must be adapted the form of the rib as closely as possible, which is sometimes scarcely to be done, since Fig. 134 shows that the line of pressure does not approach the vertical below but remains quite flat. The ellipse of the Roman vault is quite ugly for the groin, the semicircle a and the pointed arch are preferable for their greater height, and still better is a broken or a segmental arch for low vaults, that like the line of support cuts the abutment obliquely. It is important in any case to connect the lower end of the rib very firmly with the abutment, so that the line of support may be unrestricted and be left above the abutting point of the p profile of the rib and can be made secure by backing masonry. For cut stone are in place great through springing stones, but for bricks the spandrel must be also strongly connected with masonry carried high and also laid with the addition of cement. A light and subsequent filling of the lowest spandrel is very doubtful.

The very important question, how far shall be carried up the backing masonrw in the spandrel is difficult to answer in general, but for important cases it is recommended to carry up t the line of pressure with reference to the weight of the spandrel. As an approximate value may be assumed, that for the elliptical groins of a Roman vault it may be freely built to 2/3 the height, while for round and pointed arches 1/3 to 1/2 is sufficient. For slender pointed arches the backing must not be carried too high, since otherwise the crown of the arch would be forced upward. (Also see Fig. 127 with explanatory text).

Compression on the cross section.

If the cross arch or the rib becomes an actual support of t the pressures combining together, then must the line of pressure find a safe place in it, and further in no cross section of the rib should the compression be too great. As a permissible compression per q cm area may be taken on good (not porous) bricks in lime mortar 7 kil, for very hard bricks in cement about 11 kil, for cut stone in good mortar or set with lead 20

kil and more. But since the mortar in vaulting is but little hard at first, it is better to assume smaller stresses. Uniform distribution over the entire area of the cross section must o only be assumed, as already stated, when the line of pressure passes exactly through the middle point of the cross section, if it drops below to the limit of the middle third (more correctly to the bottom of the kern of the cross section), then the compression at the bottmo edge equals twice the average c compression, but if the compression becomes more excentric, then the pressure at the edge becomes still greater. (On the distribution of the compression over the cross section see Abutments below, Figs. 375 to 386). Naturally the compression on the most stressed edge must not exceed the given values per q cm. If the line of pressure approaches or even falls above the upper limit for the section, it is less important, for t then the adjacent part of the compartment takes part in the transfer of the compression. With very small or lacking ribs the parts of the compartments adjoining the edges of the groins take the transmission of the compression entirely on themselves; In such cases for larger vaults is required a strengthening m masonry on the backs of the groins (Fig. 324 below).

Example; compression in a rectangular cross section.

As a close to these considerations, let the way be briefly sketched, which would be followed in obtaining the forces for a rectangular cross section with straight edges. The compartments of such a vault have a cylindrical form, and therefore are to be divided in strips parallel to their directions (Fig. 135). A piece of rib m n is loaded by two half strips m n c d and m n b a. If it is desired to test the form of elevation of these strips, the line of pressure can be constructed for them, otherwise one can be satisfied by obtaining their pressure on the rib in a simplified way according to the proportion in Figs. 128, 129. The ground areas of the two strips are equal in rectangular vaults, in consequence of which with equal thickness of the compartments their weights will be tolerably equal also, and hence they have about equal vertical pressures on the piece of the rib. On the contrary the horizontal forces differ and that of the longer strip is mucrh larger. For equal height of ridge, equal thickness, and a form of compartment not too unlike the line of support, the magnitude of the thrust will be

in proportion as the magnitudes of the sides of the rectangle, which is the result, that the resultant of both thrusts falls in the direction of the rib. Hence a bending sidewise of the rib is not to be feared for such rectangular and also naturally for square bays. (If the thrust against the rib were greater from one side, then for the ordinary cross vault one need not be too anxious, since almost always a flatter direction occurs in the compartment, that can act as stiffening). With the vertical loads and thrusts of the separate pieces of the rib is considered as in Fig. 133 the line of pressure for the rib, t thus obtaining also the thrust of the entire vault against the supporting wall mass.

If in the preceding is left a certain freedom to static requrements in tthe form of the vault, then is the architect less compelled to make an exact determination of the forces for each vault to be erected; much rather will he be able to form a correct idea of the actual forces to be expected in his vault, t that will warn him of faulty steps.

General form of rich ribbed vaults and construction of t the rib arches.

General forms.

The form of the elevation of the ribs of an ordinary cross vault has already been explained in a special Chapter, and here will be treated the richer star and net forms. In what manner the static requirements are to be calculated have just been d developed, and then appears particularly the difference between firmly connected and freer forms of elevations afforded by star forms and the variable system of meshes based on a single general form. Earlier Gothic utilized the greater independence of its star forms, it placed the side terminal points sometimes higher and sometimes lower than the middle one, and allowed t the compartments to rise sometimes at the middle and sometimes toward the outside, entirely according to the actual need, so far as permitted by the demands of equilibrium. The later net forms must for static reasons be adapted to more uniformly curved general forms, to which men adhered the more, the more they saw themselves unable to clearly survey the ever more complex directions of the forces. Star vaults were even if unnecessarily, drawn into this course of development, so that most later vaults exhibit an expressed general form. For this the following

general types predominate.

1. Ribbed vaults of tunnel form extending over long rooms.(Fig. 136).

2. Vaults formed of intersecting surfaces, for example to form of the usual intersecting tunnel vaults (Fig. 137).

3. Domical curved ribbed vaults (Fig. 138).

4. Fan vaults (Fig. 139).

Fan vaults.

The last two deserve greater consideration, of which the fan form of vault will be placed first. In it all ribs lie in a s surface of rotation about the vertical axis of the pier. This is especially favored by English Gothic, but also elsewhere vault forms widely found have no further basis than the justified endeavor to shape the beginning of the vault as regular as possible. It is thereby obtained, that first the difference between cross arches and ribs vanishes, so that all ribs are curved to unite in their lower parts, and finally the angles in plan between each pair of ribs are as equal as possible. If these rules are regarded as required by reason of easy construction, then the fan vault originates of itself entirely, whether the cross, star or net vault is its basis. The more ribs appear, the more prominent is its regular fan or palm-like growth together, but the most perfect expression is always the entire development of the ribs over an isolated column.

Each horizontal section produces a circular ring in which lie the ribs (Fig. 140). The compartments between each pair of ribs are generally turned with horizontal courses (with ends lying at equal heights). A course may as well be either curved or straight (Figs. 140a, b).

If in the fan vault of Fig. 141 a circle is struch with a m, then must the points n o p etc. lie at one height, but the ribs rise still farther above this point to e d c. The point c will naturally lie highest, and therefore the ridge line m c rises in a wavy arch from m to c as shown by the section 141a. If t the diagonal arch a c b is pointed (Fig. 141b), then the parts a m, a e, etc., of the ribs are pieces of this pointed arch and accordingly are very simply extended in their correct form, but if instead of this the longest rib is a semicircle (Fig.141c) then will the differences of the heights of the parts be very small, and consequently the ridge will have but an unimportant

wave. This may be a reason to avoid entirely the wavy ridge o and to make it entirely horizontal. The English Gothic is aided in such cases as already shown in Fig. 48, by arches struch w with two radii, and then the ribs are only alike in their lower parts.

A particular form belonging to the latest time is yet to be mentioned, in which the ribs of similar shape terminate above a tangent horizontal circle. The square spaces left between t the circles are either closed by a stone slab or by any other suitable way.

In the fan vault the chief point is the beauty of the springing of the vault and on the contrary the form of the ridge is inferior. Conversely a graceful treatment of the middle of the vault may be placed first and this subordinated to the form of abutments, so that one is then referred to the three forms of Figs. 136, 137 and 138.

Net vaults of tunnel form.

The tunnel-like net vaults are usually employed over long rooms. Close networks of ribs lie in these vaults according to similar static requirements, like simple smooth surfaced v vaults, and therefore the most favorable cross section of such a net vault about coincides with the line of pressure for an ordinary tunnel vault of like thickness, and this curve is illustrated in Fig. 125. The form of the vault is to be determined in the manner, that the oblique ribs are pointed, semicular, or even a depressed arch. The cross section of the tunnel will therefore be the narrower projection of such an arch, the vertical ellipse produced by the semicircle, or from the pointed parts of two elliptical arcs. These projections approximate the correct line of support far more nearly than their generating curves themselves, and thus the elongated net vault of the late Gothic has a statically more favorable form than the tunnel vault of the Roman and Renaissance periods, a fact than certainly was necessary for the constructions on p. 53, when one thinks of executing vaults like tunnels with the least use of materials.

The cross compartments resolved into a network of ribs (Fig. 137) has to satisfy similar requirements of equilibrium as the tunnel, the diagonal ribs require special consideration, to them falling much greater stress than to others, therefore their st.

structural and architectural importance can be a rib section of stronger form.

Domical net vaults.

Swelled or spherical net vaults in static respects have similar favorable qualities like swelled compartments or plain d domes. If a ring stress is possible, whether from cross ribs or steep surfaces of compartments, then can the position of equilibrium move within much wider limits than in vaults of tunnel form. All cross section curves, whose curvature nowhere exceeds the corresponding curvature of Hagen's lines shown in Fig. 126, are usable for such vaults, so long as the ring compression can be safely received with sufficient safety. But there are very many such cross sections. The pointed arch is not favorable with a little lower piece, nor the round arch in a greater one, but both can be safely employed, if they receive a secure backing to the proper height.

If it is desired to form net vaults over a square bay according to an accurate surface of rotation, whose vertical axis passes through the keystone, then will result the form of a pendentive dome (Fig. 142). The springing of the vault over a detached pier will assume in plan the outline of a square that has concave sides (Fig. 142a). For rectangular bays this square passes into an elongated form (Fig. 143). The border or side arches a b, d c, etc., enclosing the bay are semicircles for the hemispherical dome, and produced by the pointed dome are curves similar to the ellipse. They are loaded particularly heavy, and therefore in the latest time are sometimes formed as stronger cross arches. Certainly men chiefly sought also to give this arch the same profile as the rib, but then an unloading of it is desirable, most easily attained when to them is given the form of a higher pointed arch with added side compartment, also favorable on other grounds. In Fig. 144 these side compartments are hatched, the middle portion left white retains the spherical form, the section through the crown is drawn in Fig. 144b, while Fig. 144a shows the already somewhat more centrally shaped impost of the vault in plan. If the impost is yet more rounded, then must the ribs resting on the concave sides at v t w would be preferred, but thus the regular surface of rotation would be given up. Finally if the springings of the ribs are brought into a regular circular plan, Fig. 145, then

is created the change of the fan vault. Thus follows a stepped transition from the surface of rotation about the middle axis of the bay of the vault to the surface of rotation about the middle of the pier. On executed works may these steps be observed in various ways.

Ascertaining the arches of the vaults.

There will be required as a rule to be chosen neither an accurate surface of rotation about the middle of the vault nor such a one about the axis of the pier, but to arrange one between the two in a proper manner.

The procedure of determining the vault will be about as follows. After the general form is drawn to correspond to the governing conditions, the plan of the ribs is determined, and one then passes to the cross section of the vault in the direction of the diagonals, the cross arches and the ridge of the vault are approximately assumed, always with the view that a graceful general shape is produced, for the last will always be sketched thus. In this main form are now the intersections to be arranged in height, where it is to be considered, that none shall seem sunken and each is sufficiently stiffened by its ribs (see on this p. 43). If then the terminal points come to lie on a surface curved on all sides, then is used with the static advantages of the latter, even not to take too much care in net forms for the assumed mutual condition of equilibrium of the intersections of the ribs. It is now to assign their forms to the rib arches, when a graceful growth from the imposts of the vault is to be especially kept in mind, and if not obtained, it is necessary to change somewhat the location of the intersections. If one can freely mostly strike the reb arches with the same radius, then may this be done with stone ribs, but with construction in brick no great practical use is seen in it. A good network of arched ribs must be so created that it can transmit its forces safely without requiring stresses through the compartments. The latter is naturallw desired for greater safety. In inserting the compartments attention is to be chiefly devoted, that for no rib occurs the danger of bending sidewis

In such wise it will be easy for smaller vaults to obtain s satisfactory forms with only an oversight of the conditions coming in question. For special cases the constructions given later will give means to undertake an examination of the vault

for its static peculiarities.

To the foreman on the work is to be given besides an accurate plan of the vault and of the springings, particularly the ordinates of the heights of each terminal point, and for swelled compartments also the location on the plan and the height of the ridge of the compartment. Never should it be omitted to take a view of the established framework of the centerings of the arches, since a fault can better be seen there than on the best drawing.

Usual rules for laying out.

The best vault will always be that in the actual case is developed from the determining requirements. For convenience some general rules of construction have been adopted, partly ascribed to the middle ages, whether rightly or not is hard to say. These rules concerning the laying out of the ribs are now to be given at the close of the Chapter, and are to be explained critically as far as necessary.

a. Ribs in a spherical surface.

a. Laying out a ribbed vault with ribs lying in a spherical surface. Although for reasons already mentioned vaults seldom form an accurately spherical surface, yet this case is first treated as the simplest (Fig. 146).

All ribs in their entire course lie on a hemisphere, whose plan is given in the Fig. If any piece m n of an arch is to be drawn in its position, length and shape, then its plan is to be produced to intersect the ground circle thereby producing the chord r s. A vertical plane erected on r s cuts the hemisphere in a semicircle, for every vertical section of a hemisphere gives such. On this semicircle conceived vertically over r s must lie the rib m n, it may then be revolved into the ground plana, which is simply done by striking on r s as a base sidewise a semicircle and erecting perpendiculars at m and n, which cut the semicircle is the points M and N. Then the arc M N is the rib in actual length and curvature, and the lines Mm and Nn are the heights of both ends above the ground plane. But that is all which is to be obtained thus. We proceed exactly in the same manner for each other piece of rib, and in the Fig. the arcs E O and a B are laid off as further examples. All ribs passing through the centre o lie on the so-called great circle of the sphere, while the others like a b and m n lie on

smaller circles of the sphere. Therefore these have smaller diameters and also a greater curvature.

b. Principal arches over the diagonals.

Laying off a vault according to the principal arch struck over the diagonal (Figs. 147, 147a). By this procedure all arches are struck with the same radius, which was not the case before. The diagonal rib is first assumed as a pointed, segmental or round arch, from one half of which principal arch are derived all other arches.

For a better comparison with the preceding construction the diagonal arch is assumed to be a semicircle, so that the principal arch is also a quadrant. The rib over a o is then given directly as a quadrant laid off as e O in the subordinate Fig. 147a, and it is now to determine the rib ofer b c and e o. For this purpose the last two lines are laid off on the ground line from the point e, as o e/ and e/ b. At e/ is erected a perpendicular to cut the quadrant, whose height e/ E gives the height of the end over e, while the arc E O is the rib over e o shown in position and size. The rib b e in the plan must lie over b/ e/, the upper end E is already found, and thus it is only to connect b/ with E by an arc struck with the given radius r of the principal arch from the point x. The centre x lies below the ground line, so that the rib starts as a broken arch from the impost. The side arches c d and h g can be made as pointed arches with the radius r to consistently carry out the principle of the principal arch; their crowns then lying higher than the adjacent ends i and f.

The vault laid out in this way agrees pretty accurately with the sphere, merely a portion of the ribs projecting onward in their curvatwre, but all intersections as well as ribs passing through the middle of the vault likewise lie in the spherical surface by this method.

Like all corresponding ribs, b c leaves the impost obliquely, but statically most are not unfavorable. But the springings of the vault by alternating vertileal and oblique feet of the ribs may have such an irregular form, that in some cases a departure from this construction is preferable.

This construction differs from the preceding only, that the broken rib line b e o (Fig. 147) on the ground line of the subordinate Fig. 148 is not laid off left from the point o, but

from a, to the right, the rib b e is found as a,E, and coincides with the lower part of the principal arch, the ridge rib e o must have one end at E and the other at a point O, at the same height as O. The arc is again struck from the centre x with the radius r. The side arches can be as before pointed arches with the same radius, but now the intersections and f will be higher than their crowns.

Thus originates a vault with regular springings, the side intersections e, f, etc. in Fig. 147 no longer lie on the spherical surface but are higher, so that they attain approximately the height of the crown of the vault. If it is desired to obtain a greater difference in the heights of the side and middle ends, then for the static reasons it is better to choose the preferable pointed arch as principal or diagonal.(Fig. 149).

Principal arch over a broken rib line.

c. Laying off according to the principal arch above a rib l line broken in plan (Fig. 150). There may be again taken the smae simple star vault of Fig. 147. The principal arch is now not struck over the half diagonal, but above a ground line obtained by adding the lengths b e and e o, and it is again a quadrant.

In Fig. 150 the plan lengths of the ribs coming in question are laid off as the line b,e,O, in course and the principal arch b,O is struck above them. The two parts b,E and E O of t this give directly the form of these arches. Also to obtain the diagonal arch, we lay off its length on plan as a,o, and then join the points a, and O by an arch. If the radius of the principal arch is to be employed for this arch, then the centre is lowered to x somewhat above the ground line, which would l lead to a horseshoe shape. But it would be better to depart f from unity of radius and make the diagonal ribs pointed.

Since the last principal arch has a longer line it leads to a greater height of the crown. If height is lacking for the c construction, a flatter line must be taken as basis instead of the quadrant, but whilh will not form a too nearly horizontal ellipse unfavorable for static reasons.

Considerations against the last rule.

The principal arch above a broken rib line appears particularly in place for net vaults, where the continuous diagonal rib is wanting, its use is also recommended for them, and still

it must be adopted here only with the greatest foresight, as will be illustrated in plan in Fig. 151.

As the ground line of the principal arch that may here again be a pointed arch, one would naturally take the rib line a e f g o, in the side Fig. 151a is the construction that presents nothing novel, most ribs being obtained directly as parts of the principal arch; the arch over a f is not contained in the rib line and is to be laid off separately as p F. If in such wise the locations of the ends and the form of the ribs are fixed, then is easily drawn the diagonal section of the v vault in Fig. 151b. But this is opposed to the simplest requirements of durability (see p. 43 et seq.), the intersection E is sunk inward in such a striking way, that the fall of the vault should be feared --- Thus we should be very badly advised to employ this procedure.

It is justly asked where this doubtful construction originated. It was chiefly circulated by Hoffstadt (Gothic A B C), and it is substantially based on a manuscript of the Danzig master mason Barthel Ranisch belonging to the year 1695, whom we can scarcely recognize as an authority. We know that remains of Gothic rules of construction have been constantly preserved nearly to our days, yet it is hardly to be assumed, that every master who had finally transformed the forms of the antique a and the Renaissance into the most silly scroll work must have preserved the traditions of the middle ages in a pure form.

That the latest period of Gothic employed in its vaults as everywhere certain mechancila rules, indeed is quite conceivable, and an explanation of them will perhaps afford numerous accurate means, that could easily be executed in the ceilings of cloisters. There is often an appearance that if such relations could be followed, whether arrangements of intersections on a spherical surface, or a course of ribs relating to a principal arch, usually are found near those arches that fit no s system. It is not quite improbable, that the use of a uniform radius, expressed in the principal arch was striven for within rational limits. From the form of the springing and the execution in cut stone this has a certain value, but the mode of c centering may have led to it. Men always set the centres first under the cross and diagonal arches, the latter even when the ribs were interrupeted in places, when the end was supported

by a vertical wooden prop. Then were also inserted the centres corresponding to the other ribs, as they could best be fixed, first the larger and then the samller, when the intersections were supported so far as necessary. It was everywhere a convenience to set beforehand the centering for rich vaults, to draw them with the same radius, then fitting and cutting them just as required. Thus many reasons may have combined to cause the endeavor for a consistent execution with the same radius. But where this led to injurious results, there a thoughtful architect in even those days would not have carried the love of a hard worked principle so far as to have sacrificed to it the beauty or even the safety of his work.

6. Form of sections of ribs.

Projecting ribs of vaults generally occur, since after the 12 th century, not the vault surfaces but the vault lines were the determinants for the treatment of the vault. (See p. 11). Then was rapidly completed that important change, the new forms of arches were introduced that changed the shape and the execution of the surfaces of the compartments and received its crown when the supporting arch was separated from the supported surface.

The most effective impulse toward the introduction of the ribs was given by the difficulties in the construction of the irregular groin angles and the great stress in them by the forces transferred just by these intersecting lines.

The cross section of the ribs must first afford the required bearing for the courses of the compartment, but then be suited in dimensions and shape to properly receive the corresponding loads with sufficient safety, thus dividen in two parts, the upper abutment and the moulding projecting beneath.

Consideration of the compartments.

The support required by the courses of the compartments either consisted of a flat surface (Fig. 152), of two roof shaped surfaces inclined to each other (Fig. 153), or of a back extending through both compartments, with its sides best so inclined as to receive the compartment at right angles (Fig. 154). This projecting back occurs both for cut stone and brick in the earliest period, as proved by the earliest sections belonging to Gothic (Figs. 195, 196). From the ruins of Walkenried in the Harz mountains and the remains of the abbey church of Chorin,

likewise from the 13 th century. Brick architecture especially adopted this form of support, that also again became the favorite for new structures. It had the advantage among others, t that the rib could not move beneath the compartment, which is occasionally observed in old works (Market church at Hanover). An interesting section belonging to the Renaissance and perhaps imitated from earlier works is found in the ruins of the church of the order at Doblen in Courland (Fig. 155), that sows a dovetail back that must have been advisable when the compartment partly sprung from the ribs. Instead of the reduced backs the brick ribs usually show a back of the rib piece in its entire width, as at the entrance of the German Catholic church at Wilna, at the cloister of Riga cathedral (Figs. 156, 157).

Moulding.

As for what concerns the moulding of the part projecting from the surface of the compartment, this is extremely varied, yet is alwayu first dominated by the law of resistance. For the strength of a certain arch first depends on its depth. If a movement sidewise does not come in question, and the arch has receive predominating vertical loads, then the breadth has far less importance for its resistance . This predominating importance of the depth must be expressed in the profile of the rib, both in its dimensions and the character of the mouldings. Therefore the height is to be made at least equal to the breadth and better more, so that it is to the breadth as the diagonal of a square to its side. The ancients very soon recognized the importance of depth, and this is often expressively emphasized already in Romanesque cross sections.

In form the cross section of the rib naturally tends in its basal form to the far older arches, as in these were the rectangle or the round. The rectangle sometimes appears in the first occurrence in the simplest way indeed in the simplest form in the ribs of the crypt at Gloucester belonging still to the 11 th century (Fig. 158). But mostly as for cross arches the angles are more richly treated, for example in Notre Dame at Paris (Fig. 159), or are merely chamfered (Fig. 160). Instead of the early chamfering at 45° there often occured later a steeeper and more expressive direction of about 60° (Fig. 161). The round appears up to the transition time as a simple semicircle with or without stilting (Fig. 162), but it is most fre-

frequently attached to a rectangle (Figs. 163, 164).

The predominating importance of the height is most clearly expressed in the last form with two parts placed below each other, and this therefore also became quite particularly the starting point for further changes. An example of this kind is shown in Fig. 165, taken from a side chapel of the cathedral in Fritzlar and in a measure may be regarded as the root of t the richer forms represented in Figs. 166 to 172. In the choir of the churhc at Wetter the lower member is reduced and the c chamfer is replaced by a cove in Fig. 166. In the nave of the same church a few years later the connection between the cove and the vertical slab is made by a chamfer (right half of the same Fig.). The effect is still heavy here but is better if t the cove is cut deeper (Fig. 167). Yet more strongly is the c cove separated from the vertical side surface by a round inserted between (like the profile of the rib of the collegiate church in Treysa belonging to the 13 th century, Fig. 168) and to the cathedral at Magdeburg (Fig. 169). This round is sometimes repeated in smaller form before the beginning of the cavetto on the rib as in the chapter hall of the monastery of Haina in the 13 th century (Fig. 171), of Cologne cathedral (Fig. 1 170), and in the Marburg castle chapel founded in 1288 (Fig.172)

Simple forms directly result from the chamfered rectangle ((Figs.160, 161), if the oblique surfaces are replaced by flat cavettos (Fig. 173), from which then by doubling or deepening the cavetto are developed the form of Figs. 174 and 175 belonging to the late period.

The purpose to more clearly express the intersection of the ribs led in the late period to a general use of the cross section divided below and represented in Fig. 176, but which also occurred already in the earliest time on ribs and cross ribs.

Lower round of the rib.

As shown by a glance at the given cross section shown, most end below in a round. As a rule this is shaped by the compasses, (Fig. 171), also being sometimes drawn from two centres, either as a pointed rib (Fig. 178) as it occurs already in the earliest time, or as a wide depressed round (Fig. 179), such as late Gothic works indeed show it.

To the round was already added in the 13 th century an addition henceforth peculiar to it in the form of an edge or fillet

extending along its lower surface. This edge composed of two intersecting surfaces first occurred, but was soon followed by the projecting fillet in Fig. 181, which then became more commonly employed than the former. The use of this member might have been prepared by the pointed profile in Fig. 178, and even might favor setting on the centering, yet the main reason for its introduction must be sought in the artistic effect. With the great height and the confused lighting a simple round easily appears rather uncertain, the shadow limits often extending as long wavy lines on it. On the contrary the eye clearly sees at a glance the shape, if it can pass along a sharp projecting angle. Since only bold members are effective in this place, t the fillet soon projected quite strongly until the pyriform s section of Fig. 182 was reached.

In Fig. 182 is indicated how this form of round was composed of circular arcs. Such a sketch in circular lines was not always the rule in the middle ages, but much rather measurings of cross sections of ribs from Cologne, Aix-la-Chapelle etc., show that these members like many others were frequently drawn freehand in pleasing curves.

Sometimes fillets were added on both sides of rounds, which project so far, that they nearly or quite unite with the bottom fillet, allowing the round to vanish as in Fig. 183. The other little rounds of the rib were later also furnished with an edge or fillet, which then also passed on the members extending down the pieces as well as on the moulding of the window jambs etc.

General form of cross section.

If one places on the cross section of the rib a series of l lines touching the high points, he recognizes that generally in the course of time the rectangular ground form disappeared more and more, and on the other hand the shape of a triangle pointed downward ever became more expressed.

Such a series of lines enclosing a cross section or its principal points (for example the centres of rounds and cavettos) frequently and undeniably exhibits a regular geometrical figure, for example a square, isosceles right angled triangle, an equilateral triangle, etc. 1 : 1, 1 : 2, also 3 : 5 (about the golden mean), as well as occasionally the ratio of the side to the diagonal of the square.

It is not to be denied, that a basis of such simple relations greatly facilitated the existence of an expressive form, aid further the convenience of starting points for sketching and executing a block of stone. This advantage was also justly utilized by the middle ages, but in the best period at least the true limit was never exceeded. The cross sections of the ribs show that geometrical constructions first come in question only after the requirements of resistance and of artistic expression had made their rights felt. The vault arches appeared confused in the broken light and foreshortened at a great height, and even exhibited requirements in their mouldings, that scarcely were expressed in the geometrical ratios of the cross section, but much rather appeared in the entire peculiar forms of the members, for example in the origin of the pyriform mound.

Relation between rib and cross rib.

When the ribs first appeared, they were sometimes made as large as the cross rib, thus on many French works from the end of the 12 th century, as well as in Germany at Walkenried, in the choir at Magdeburg, etc. But men soon recognized that the ribs only required a smaller cross section, and therefore they were made generally weaker than the cross rib, as already usual in Romanesque works in Germany. That was rightly done, for then the stilted vaults usual at the time like domes, transferred a considerable load to the cross rib. A strong cross rib further gives a desirable and firm resistance of the opposite pier to variations of loading, wind pressure, etc. But especially necessary is a broad cross rib where adjacent unequal vaults exert different side thrusts on the cross rib. Where extra loads of masonry or the framework of the roof is entrusted to the cross rib, a corresponding strength is also naturally required for it.

Such reasons can demand very great strength for the cross rib, where however they do not appear too compulsory, one is satisfied by assuming the difference in width between cross r rib and rib at about 5 : 3.

Where in many forms of vaults of the advanced Gothic period there is referred to the cross rib only the work of an ordinary rib, it was quite logical again to make the size and form of cross section exactly like that of the other ribs. For the elongated net vaults the cross rib was often externally omitted.

But as soon as a reason occurred for the existence of the cross rib, it appeared in the latest time in a moderate size.

The cross section of the cross rib is mostly a rectangle with more or less richly treated angles (Fig. 184).

Cross section of the cross rib.

Very frequently is placed a semicircular or polygonal projection under the rectangle (Figs. 185, 186). Of these forms the Gothic takes particularly the simple rectangle, which is membered iy the most varied ways. The chamfer, cove and still more the round remain favorites in the entire Gothic period. When the breadth was relatively small, already after the transition period the lower surfaces quite back off and on, so that the double forms in Figs. 188 to 191 result. Figs 189 and 190 are taken from the choir vault of Magdeburg cathedral, while Fig. 191 found egploymeent at Strasburg, Freiburg, etc.

Other more frequently occurring forms are given in Figs. 192 to 194.

The membering of cross ribs and ribs differs as shown in the examples represented, generally from each other and are often quite different in the same vault, even if an extensive harmony is always intended. Even in those of the earliest works, that exhibit cross sections of equal sizes for both ribs, the members often vary as shown in the compared examples from the abbey church of Walkenried. (The same cross sections are found over the upper choir aisle of Magdeburg cathedral and on the nobles' refectory at Maulbronn.

The correct feeling expressed in the different examples of the actually supporting and the occasionally bearing and dividing cross ribs in the membering is followed in late Gothic, but besides it occurs also quite early the endeavor to treat both ribs alike. In many cases the cross section of the cross rib is merely a widening or enriching of the form of the corresponding rib. Thus the forms represented above are in great part transferred to the cross ribs, and an example of this kind is reproduced in Fig. 198 from Cologne cathedral.

In determining the membering of both ribs it must not be overlooked, that beautiful and regular growth of the same at the springing of the vault (see that) must determine their forms.

Like the pier ribs, greater cross sections of cross ribs are composed of several layers of stone above each other. In the

earlier time also in brick in rowlock arches was favored, where now the bricks are set in the usual bonding. A brick cross rib from the 13 th century from the chapter hall of the cathedral at Riga is shown in Fig. 197.

In the later time the upper angles of cross, diagonal and s side arches are frequently replaced by slopes (Fig. 199), by which in the execution results a neater junction and a rather desirable bearing for the placing of the centering.

Side arches.

Side arches may either project from the face of the wall or lie in it.

In the first case (Fig. 200) the side arch is bonded, i.e., the ashlars or bricks composing it extend for at least half the arch into the wall, and therefore must be set with the erection of the same and project with at least half the members of the corresponding cross rib, or better have an independent section before the face of the wall and form with its back a curved ledge on which the compartment rests.

Where the side rib does not project from the face of the wall, then must this bearing b be formed by a groove sunk in the wall corresponding to the side arch. This recess in Fig. 201 is sometimes formed in works executed with a certain economy in ashlar masonry by cutting it in the usual bond of horizontal and vertical joints, afterwards striking the true circle. In rubble work the stones are sometimes merely set back in the ordinary bond, whereby very irregular rib lines result, or in brickwork is formed by theee concentric arches (Fig. 201), although by the last method compared to that of a bonded side arch, easy execution is scarcely obtained.

In the early time it was especially common to recess the wall above the side rib, whereby a safe bearing was produced in the simplest manner possible above the side rib. An example in cut stone is shown by the ruins of the church of S. Maria at Lippstadt (Fig. 202) and a similar one for brick from the cloister of Riga (Fig. 203).

Size of the cross section of the rib.

On the absolute size of cross sections of the ribs of vaults it is difficult to make an absolute statement. As the statements of the preceding chapter (p. 59) teach, the magnitude of the compression to be transmitted by the ribs come into consid-

consideration less than to receive it correctly at the middle of the cross section, or in other words the proper position of the line of pressure. It it is desired to calculate the section of the rib only according to the magnitude of the compression, then would usually result sections of such small dimensions as to be practically not executed. With regard to a safe reception of the line of pressure, the size of the section is properly not to be limited too much. It is assumed in practice that subordinate ribs of cut stone 15 cm wide and 22 cm deep should s suffice for vaults with diagonals to about 9 m. Brick ribs of the cross section of a flat brick (12 × 25 cm) including some back projection will often be executed up to nearly the same span. But it must be recommended to increase the section for such spanr by large special bricks or by several bonded bricks. To this can be added in place a thickening of the compartments over the back (compartment masonry above).

As the lowest limit for the breadth and depth of the cross section of the rib may be designated indeed 9 and 15 cm, although for small bricks nothing prevents making,them still smaller. In fact we find also on old works sometimes yet smaller sections, for example in the triforium of the church of S. Mary in Stargardin Pomerania being those whose projecting portion measures only about 8 × 10 cm.

The erection of rib arches will be mentioned in the last Chapter (centerings etc., p. 118 et seq.).

7. On Closing Stones.

Keystones of arches.

Closing stones of masonry arches.

For a simple wall arch it is in structural respects most immaterial, whether it shows a joint or a stone at the crown. Yet it was a rule that the Romans had to give the middle of t the arch a keystone, which became a favored ornament as on the triumphal arch. The middle ages abandoned this rule and according to daily judgment sometimes ordered a joint and sometimes a stone, but in the pointed arch the joint at the crown is even preferred; Figs. 204 to 207. The other joints raidate from the centre of the braoch of the curve. With small stones or bricks were not avoided intersections formed as in Fig. 206. Only occasionally as at the city gates of Pisa (middle of the 12 th century) did men strive for a gradual transition in the directio

of the beds, when either a part of the upper beds were allowed to run toward a different centre d (Fig. 207), or all beds were directed toward a common centre c. In brick arches such a gradual transition is more common.

But a separate keystone is not rare for pointed arches, but was especially employed for heavily moulded arches to make possible a more solid junction of the members (Fig. 208). The hook-shaped reentrant angle at a sometimes afforded opportunity to form there a projection (rosette) or a cylindrical body growing out of the lower members of the arch. Examples of this kind are shown by the side arches of the minster in Freiburg. That this filling in slender arches is statically favorable is shown in Fig. 127 E.

Keystone of the vault.

Closing stone of the vault.

Among the vaults the tunnel like the wall arch may have a c continuous joint or a closing course of stone at the crown. Naturally a single keystone cannot be mentioned for a vault, for this first comes in question for vaults with raised middle and for cross vaults. But all real importance succeeded the keystone for ribbed vaults. Here unite at the crown of ordinary cross vaults four rib branches at a point, six in the hexapartite vault, and frequently more in the choir and star vaults. Such a closing stone has also to satisfy requirements of strength, of solid execution and of beauty, for it must hold fast the branch ribs and unite them immovably, make safe a transfer of the middle, must receive the arch members in an ornamental way, and also finally have a worthy appearance as the climax of the internally visible construction.

Simple intersection of the ribs.

To this importance of the keystone corresponds the fact, that it was strongly accented already in the Romanesque period after the appearance of the first ribs and was richly treated. Only the more modest works show at all times a simple intersection of the rib mouldings. Thise will first be mentioned ar simple coverings of the rib branches forming terminal points.

It is theoretically permissible to allow the mitred ends of the ribs to meet in the goints a b, c d, etc. in Fig. 209, as frequently occurs in brick ribs. But it would be difficult to carry out this in stone, with acute easily broken edges, incon-

inconvenient setting (especially with many ribs), easy displacement and finally an ugly appearance of the joints. Therefore only one arrangement can come in consideration, which makes t of a single common cut stone the middle part with projections for each rib (Fig. 210).

The size of the closing stone is arranged according to the size and number of the ribs; where sufficiently large cut stones are at hand, it is advisable not to make the separate projections for the ribs too short. On the contrary if there is a reduction in size, all projectins will be made so short that the mouldings can develop freely.

Independently developed closing stone.

When the ribs meeting in a closing stone have different forms of arches, thus striking the closing point with different inclinations, then must the projection for each rib be made by itself. In this case the members of the different rib branches do not regularly intersect, but the intersection of the ribs acquires an ugly appearance. Moreover since there the unity of the importance of the closing stone is not expressed, and thus the useless removal of a considerable portion of the stone is required, and the middle ages preferably replaced the naked intersection of the ribs by an independent form of closing stone, that shows the most manifold variations. Men inserted between the ribs a round or angular body, that frequently extended into a ring. Then the junction between two ribs was enriched by foliage or angels' heads, or it was concealed by a great d disk placed beneath, or finally the closing stone was allowed to project far below and it was covered by rich plant and figure ornament.

A particular favorite was to allow the ribs to terminate against a cylindrical nucleus on which the projections for the ribs were cut, so that now the entire closing stone received the form given in Fig. 211. It was next to omit the projections for the ribs and to cut the sides of the nucleus with the radial directions of the separate arches, thus giving it a conical form. But since the junction of the joint surface of the ribs with a round surface demanded a conical form thereby caused a flushing of the courses (Fig. 211a), small projections then always became necessary and made a conical form of nucleus unnecessary, since on it was formed the radial joints. The least

radius of the cylindrical nucleus was the length b a; as a rule it was made greater, so that the surface of the cylinder was everywhere visible between the projections for the ribs. At t the height of the face of the compartment this cylinder is reduced, so that a projecting ledge remains, and the smaller diameter continues through the thickness of the compartment as s shown in Fig. 211. As a rule for cylindrical closing stones t this recessed projection that passes through the thickness of the compartment is round. It then chiefly exists when these remain without starts for ribs, and is necessary for closing stones with an opening in the middle.

On certain works from the beginning of the 16 th century t the portion of the closing stone passing through the thickness of the compartment has a greater diameter than the visible cylinder, so that the projecting ledge is formed in the converse sense, that lies on the backs of the ribs.(Fig. 212). The ribs themselves terminate then at the sides of the cylinder with a vertical joint, but to avoid a hollowed form of the joint surface are let into the surface of the cylinder. Likewise the b backs of the ribs must pass so far under the projecting ledge of the closing stone and be dressed horizontal if the rib is not horizontal next the middle. But both requirements make the construction disadvantageous.

The moulding of the ribs is generally carried around the sides of the cylindrical nucleus of the closing stone (Fig. 213); frequently the member also takes an entirely different form as in Fig. 214. The last arrangement is preferable when the ribs are pointed arches, since on account of the oblique joint against the closing stone, the moulding on the latter will have a different and much higher form. When the ribs join at different vertical angles, carrying the same moulding around the closing stone is usually no longer to be attained, since at each rib a different section of the moulding is formed, and it then remains best to leave the sides of the closing stone entirely plain. The mouldings of the closing stones in Figs. 213 and 214 show a projecting disk beneath, that affords opportunity for rich ornamentation (see below). On many early Gothic works, these disks project far beyond the projections for the ribs, so that the junction of the ribs is concealed, as at the monastery of Walkenried and the collegiate church at Lippstadt. I

is unnecessary for a cylindrical nucleus to exist above this disk, and thus in Walkenried (Fig. 215) the ribs simply abut against each other, after having been changed to a rectangular cross section. The disks beneath instead of the round shape, often assume an entirely independent form as a trefoil, quatrefoil, or even a combination of the trefoil and triangle oh the quatrefoil and square.

But sometimes such a form of ground plan is directly carried up as a nucleus, so that all lower projection is omitted, and the members designed for the sides of the members now extend around this basal form. Fig. 216 exhibits such an example, where the ribs enter the projections of the quatrefoil, while with a round nucleus they could also have joined in the direction a b.

Usually the round ground form of the nucleus is merely conventional. It certainly affords the advantage, that the ribs passing in different directions toward the middle of the closing stone intersect the side at right angles, but the originally square shape of the block now appears only in the projections for the ribs. But more clearly expressed is the cut block in square or approximately square form of the closing stone, as shown in Figs. 216, 217. In the rectangular end of the choir of the church of Volkmarsen the ground form of the closing stone is a diagonal square, so that the ribs join its corners. On the underside is found the lamb and the banner of the cross in a panel sunk by a flat moulding, in the angles of which are made four rosettes. Likewise as the closing stone not rarely found in the form of the vesica piscis, then bearing a figure of S. Mary.

But in the cloister of Erfurt cathedral is also found the converse arrangement, for the nucleus of the closing stone is in form of a square or flat four ribs, the ribs joining its sides and their joints are here concealed beneath by an attached and richly ornamented disk (Fig. 218).

Loading the crown. Pendent closing stone.

The size of the closing stone is not capriciously assumed, for round arched ribs could support only a light closing stone, while conversely steep pointed ribs require a greater load at the crown, whose magnitude can be found by constructing the line of support. The load on the crown can be obtained by a

corresponding breadth and depth of the closing stone, or in s some cases by a great specific weight of the building material.

Usually the closing stone projects below the lowest bottom of a rib as shown by many examples mentioned, thus in Figs. 215, 216, 218. This drop either remains plain on the underside and only has a moulding around its edge, or a more or less rich ornament is given to the mass, and expresses the loading of the crown demanded by the upward pressure of the pointed arch, and at the same time affords opportunity by its richer execution for bringing to a conclusion the effect of the vault in ornamental respects.

In every case must be taken care for this projection in establishing the centering, i.e., the upper edge must be made sufficiently low at the crown as to leave space for setting the pendant closing stone. Further see under Centerings.

The principle of loading the crown, which in general led to the pendent and the decided treatment of the closing stone, is yet more clearly expressed by the form of the pendant.

In the simplest case this takes the form shown in Figs 216, 218, because the separate leaves have a position more approaching a vertical plane, and thus assume the appearance of corbels or capitals. In the church of S. Mary in Mühlhausen is found a pendant stem on which are placed two rows of leaves each almost like cross flowers (Fig. 219). In this case with the low shape of the diagonal ribs not exceeding a semicircle, where the loading of the crown was entirely unnecessary, caprice is undeniable, yet the refined sense is wonderful, by which was attempthe the transformation of the cross flower, instead of merely reversing it and leaving it unchanged.

Another is more labored, since an affected structural significance in the form of the closing stone is found in a bay of the northern side aisle of the cathedral of Mayence, where it assumes the form of a suspended canopy of square ground form, against whose angles terminate the ribs. Likewise belong there the closing stones that represent the springings of the ribs as resting on a rising corbel, so that also the projections f for the ribs instead of penetrating the nucleus in continuation of the rib arches, are bent near the joint and spring in an arch of smaller radius from the corbel forminm the lower ending.

But the entire principle is carried to an extreme and appears

in the exclusively late Gothic design of the suspended vault, that is especially common in England but more rarely found in France and Germany. An application of this construction to the plan of the net vault is shown by the cloister of S. Stephen in Mentz. The closing stone has here become a formal suspended column and like an actual hanging column with struts in wooden construction, thus it here supports the ribs of the true vault above, continues down to the height of the ground line of the vault and ends in a free knob. Above the knob are then found the projections for the rising ribs. Fig. 220 exhibits this c construction in section. There is the closing stone supporting the arches, b is the suspended closing stone, c the ribs and d the compartments of the vault.

The rich and picturesque effect of such vaults expiatees in their reality the exaggeration of the principle. However it m may be regarded as a mere decoration, and thus forming only an accessory development from the construction, in nowise merely something fastened or glued to it, in which production architecture is so rich.

Broad development of the closing stone.

It was shown in the preceding how far the development in height of the closing stone could be carried, so on the other h hand is it also capable of a greater breadth. Particularly the meeting of a great number of ribs leads to an enlarged closing stone. In many works of the transition period, especially in the Westphalian churches at Billerbeck, Leyden and also in the great church of S. Mary at Lippstadt as at the cathedral at Minden, the meeting of eight ribs has been so arranged, that only four extend to the closing point, while the other four are received by a concentric circle. See Fig. 211 for the church at Billerbeck (after Lübke). There are to be mentioned here similar more sportive treatments of the middle of the vault, among which is a great ending of ribs like a wheel in a vault of the middle aisle of the cathedral at Paderborn is particularly prominent.

Perforated closing stones.

Large closing stones are frequently perforated, and also smaller ones have often received central openings. The perforations may serve for very different purposes, for lowering ropes for scaffolds, hanging chandeliers, ventilating the interior,

and finally are intended for hoisting larger objects like bells. In arranging the openings for emission of air is necessary a certain economy, since especially in little churches there easily originates an unbearable draught, which at least leads to the temporary closing of the opening.

Around the inner side of the opening sometimes extends again the moulding of the ribs or one entirely different (Fig. 222). Usually the sides of this opening are also simply vertical as in Fig. 231, it forms in a certain sense the middle of a rosette as in Fig. 231, or it is otherwise connected with the ornament of the closing stone as in Fig. 216, where the perforated opening of the mouth of a head represents it.

Those middle openings further enclosed by a circle of ribs in vaults, required for hoisting larger objects to the upper rooms like attics of towers, were also executed in vaults with compound rib systems. The opening itself is then generally closed by a stone slab laid over it or by a lighter removable cover of planks.

Piece of rib.

With an unequal length of the sides of a bay, there will remain considerable spaces between the beginnings of the ribs on the sides of the closing stones in the direction opposed to l longer sides, while in the directions opposed to the shorter sides the beginnings of ribs may join each other. In such cases these intervals are sometimes decorated by heads projecting f from the sides of the closing stones. Such an example from the former Franciscan church in Fritzlar is shown in perspective by Fig. 223. The same case occurs on the closing stone of the hexapartite cross vault, as for example in the southern transept of the cathedral of Wetzlar, and further in those of the choir vaults (Fig. 224). In both the last cases is found the same, an arrangement of such heads producing a very happy effect. Viollet-le-Duc gives several French examples of this kind.

In a different manner are the inequalities of closing stones of choirs lessened, if the closing stone is moved a bit a b in Fig. 224a from the middle of the polygon, but where the direction of the ribs toward the first point remains unchanged. Thereby is indeed produced a more oblique and irregular position of the starts on the cylinder, and also the heights at which these sometimes succeed are changed.

In Fig. 224a the middle lines of all ribs meet at the same point a in height. Now since the distance c x to the junction of the rib is less than from the same point for the rib d y, thus a c is smaller than a d, d will be lower than c. Hence t the closing stone must have a depth greater than is required by the junction of one rib, and this extra height must equal the difference in the heights of the points c and d. But the lines of the backs of the cross sections of the ribs also strike the closing stone at different heights as well as the two sides of the same rib. Thus the point f lies higher than the point g of the same rib, and both are again higher than the also unequal points e and h. Therefore the compartments also join the closing stone not in a horizontal line, but in one r rising from h toward i, and hence the before mentioned ledge of the nucleus must be wrought to such a line (Fig. 211). The entire construction is expressed clearly in the perspective of Fig. 224b, where for greater clearness a pointed form of the rib arches is assumed, such as usually occurs in practice, so that both the irregularity of the joinings and also the inclined position of the projecting ledge of the nucleus appears in labored distinctness.

Quite similar conditions require the forms of closing stones if the ribs join with different inclinations. Fig. 225 will m make this condition clear, and there is the proper crown of the vault. At the left side of the Figure are drawn the joinings of two ribs, both being directed to c. Hence the steeper one meets the surface of the closing stone lower at b a, but the flatter is higher at d e, so that the entire depth of the closing stone must be b d.

All these irregularities may be avoided when the junctions of the ribs have a horizontal transition as in Fig. 225a, and the arches of the separate ribs are accordingly constructed so that they are not struck from the point c, but from the points d and e, that would be shown by the first closing stone to be constructed.

Esthetic development.

It still remains to cast a glance at the esthetic development of the closing stone. In whatever manner the side surfaces are formed, membered by varied mouldings or enriched by projecting heads, etc., is already shown at the proper place. Yet more was

busied the artistic joy of creation in the mode of treatment of the underside, and there Gothic ornamentation proved itself as an inexhaustible wealth in the most splendid manner. These closing stones, like the sun in the vault of heaven, frequently in even the dryest works are found most richly adorned, forming the sole decoration of them. This effect was again heightened by the often still visible painting not merely of not merely the closing stone itself, but also of the adjacent parts of t the ribs joining it, unfortunately now in most places made unrecognizable by whitewash or dirt. The destruction of the splendor of color is the more to be regretted,,since even the relief treatment of the foliage was so arranged, that it required color in many and indeed in most places to make visible, how the separate leaves entirely flow into each other, no longer separated by color but blackened by smoke.

We can here merely specify the principal modes of treatment and illustrate by examples taken for the reasons mentioned, in great part from the smaller churches, cloisters etc. The simplest treatment originates when the ornament is sunk into the underside of the cylinder, so as to leave it enclosed by a border lying in this underside.

Forms of this kind are frequently found even in the transition style, as in the vaults of the cathedral of Mayence, but in the later time they chiefly appear in very simple works. An example from the church in Trendelburg near Karlshafen is shown in Fig. 226. It is better when the ornament joins a disk projecting downward, so that its recesses no longer extend into the nucleus further than to the bottom of the ribs. A sunken wrought ornament then either lies on a surface recessed by a member as in Figs. 232, 232a, or on a flat sunken underside as in Figs. 230 and 231.

Usually it also occurs that the foliage without an enclosing border springs strongly and directly from the underside of the closing stone and not rarely projects beyond the border. Examples of this kind are shown by Figs. 227 from the church in Trendel burg with section in Fig. 227a, then by Figs. 228 and 229 from the church in Volkmarsen (Fig. 228a is the section of the latter), Fig. 216 from the cathedral in Freiburg, Fig. 230 from S. Blasien in Mühlhausen. Sometimes the foliage also lies on the disk concealing the underside of the closing stone,

as shown by Fig. 218 from the western side of the cloister in Erfurt.

The arrangement of the foliage is extremely varied. In the simplest case the leaves radiate indeed from the middle of the edge, or more rarely in the reverse direction as on certain closing stones from S. Blasien. In the first case is thereby prudoced a rosette, either single or filled by several rows of leaves. The arrangement of such rosettes is the advantage of easy recognition, and sometimes is found as the conventionalized imitation of a rose, as shown by Fig. 227 in a form belonging to the 14 th century.

Instead of the straight position the separate leaves are sometimes curved sidewise as in Fig. 228 or placed in a cluster as in Fig. 232, or they are mixed with leaves directed otherwise, so that the rosette entirely disappears as in Figs. 229 and 216, or finally the ornament consists of a branch laid on the underside and bent in a circle, its leaves then covering the surface as in Figs. 230 and 218.

In the earlier examples like Fig. 231, the ground between the separate leaves is still visible and the modeling is merely indicated, so that the leaf is chiefl: effective by its outline, while already at the end of the 13 th century the modeling gains so much in projection, and the leaves lie under and over each other, that the ground almost disappears, but the perception of the whole suffers as in Figs. 228, 216. Yet in both c cases is still retained a general effect, in the first by the symmetrical arrangement and in the latter by the head placed at the centre. Yet attention is called to this, that the effect is essentially richer if the separate leaves alternately show their upper and under sides as in Fig. 229, whereby at the same time ttheir different colors have a motive. Just as in Fig. 216 the head forms the centre of the closing stone, such often forms the entire ornament so that to obtain a regular form either the hair and beard are utilized or the latter is replaced by leaves.

Usually figure ornament produces the richest and most beautiful decoration of the closing stone. Here belong first the symmetrical representations, such as the symbols of the evangelists, the pelican (Fig. 234) from the cloister of the cathedral in Fritzlar, the lamb with the standard of the cross, etc.,

then the sun and moon (Fig. 226), or even more fanciful animal forms like Fig. 233 from the eastern side of the cloister in Erfurt. Particularly in such forms does the refined feeling for ornament strive, that guided the forms of the ancients. Thus all animals are conventinalized with wonderful intelligence, that is derived from their natural peculiarities so much as necessary for their designation, and thus by the stronger accenting of these peculiarities, by the omission of all indifferent parts is obtained a representation, which expresses the desired object in a more acute way. The most decided opposition to this method of treatment is found in so many modern symbols, that are formed in the most naturalistic manner, and allow the characteristics to appear so indefinitely, that the most amusing alterations are produced. Thus the lion is now represented with metal hair and is scarcely recognizable at the least distance, the hair does not cause a clear outline of the form, and merely forms a covering of the mass. The outline should reproduce the natural sharpness but loses definiteness and energy, the movement is crippled and the entire conception is far removed from expressing in the least the idea of the lion. Likewise is it with all other heraldic figures as well as with most of those animal forms, that afford an integral portion of modern ornament. As in so many cases, here mediaeval modes of representation agree with the antique, but the modern is entirely opposed. Thus for example in the collection of Roman antiques and casts in Mentz are certain animal forms engraved on helmets, shields etc., that could almost be held to be mediaeval drawings.

Figures are found on the cloisters already in the first times, particularly of the holy Virgin, the patron of the church or of the order, angels, etc., but frequently also a representation from sacred history, especially common being the coronation of S. Maria. Beside the figures there sometimes remains a free space on the cloister filled by foliage that encloses the figures. Of the greatest beauty are such examples in Viollet-le-Duc's Dictionary. Also the arms of the founder, even cities, families and states find there place there. Sometimes are even found vacant shields on which probably coats of arms were originally merely painted. See Fig. 217 from the church in Gottsbüren.

Intersections of ribs beneath the crown of the vault.

In star and net vaults occur intersections of the ribs that

lie below the crown of the vault; these always afford opportunity for irregular forms, whether they arise from a mere intersection or against a closing stone . The difficulties result because the cross section of the ribs are not perpendicular to all directions of the vault, Fig. 235, but are everywhere vertical underneath, Fig. 236.

This difference shows little or not at all for the diagonal ribs, but very strongly for the transverse ribs. In Fig. 235 where the cross rib is perpendicular to the direction of the vault, the members of both ribs intersect regularly, but on the contrary in Fig. 236 is found an irregular intersection. the ribs are arranged so that at least their lowest edge was predominant, and the reason for it is that the radial arrangement of the ribs leads to other and greater difficulties, and makes difficult the placing of the centerings as well as the cutting and setting of the ribs, and finally leads to the curved projections of the ribs on the plan, as they were actually executed in the late time.

The irregular intersection of the members of the ribs, which is observed on all net vaults, is not very embarrrassing and even increases the variety of its appearance. The particular difficulty of the arrangement increases by the junction of the compartments to the backs of the ribs, that lie at different heights at the intersection.

The angle r of the cross rib rises in Fig. 236 by the distance r s above the back of the other rib. Accordingly the cross rib requires the cross rib to be set at the height r, but not the main rib which is set at the height s. These requirements are only combined by raising the lower back by a wedge-shaped f r to the same height or in any case so that the other ribs are reduced in height.

At the other side of the cross rib the condition is reversed, and here the back o′ of the latter lies too low by o p. Accordingly here the cross rib must be raised at one side, either by an upper surface inclined sidewise (Fig. 237), or by anprojection (Fig. 238), and finally by the existence of an abutting fillet can be obtained by the additions of different heights at both its sides (Fig. 239). The entire intersection will have its form shown with the assumption of the stepped back of Fig. 238, in perspective in Fig. 240.

Covering the intersections.

Another intersection of the ribs is represented in Figs. 242 to 242c that corresponds to the point A in the net vault of Fig. 241. The intersection is symmetrically formed at both sides of the axis MM. Fig. 242a shows that a wedge on top is necessary as for the two lower additions of the ribs, and Fig. 242c shows the cut block for the case that an abutting fillet exists on the back of the arch. The intersection of more or l less than four ends of ribs is arranged according to the same points of view. As a rule these intersections of star and net vaults consist of a simple crossing, while only in the ridges are arranged actual closing stones. But sometimes there are found in the angles between the additions to the ribs leaves or clusters of leaves. The same treatment however occurs also on the closing stones in the ridge. Likewise the view of the intersections from below is sometimes concealed by a more or less richly ornamented disk lying on it.

On the contrary more rarely is the intersection avoided by the arrangement of a cylindrical nucleus. The position of this cylinder strictly taken must be perpendicular. The case when the projections for the ribs extend obliquely from the nucleus may lead to make these inclined. But it is undesirable that the vertical position of the side surfaces of the rib sections is in essential conflict with the inclined position of the surface of the cylinder, and thereby another arrangement is sought, as an intersection concealed by foliage might represent the proper treatment. An extremely rich and happy treatment of such intersections is shown by the choir vaults of the church of S. Martin in Cassel, where the twelve crossings of the ribs are concealed by the sculptured figures of the twelve apostles cut on the respective ashlars, while the closing stone of the whole bears the crucifix.

Forms of the late period.

In certain works of the late Gothic the intersections of the ribs are so intentionally labored and enhanced, that one of t them not continued beyond the intersection is extended as a short piece purely for ornament and is then cut off at right angles. Fig. 244. For this is sought a certain reason. Yet it might appear more correct to allow the part of the cut stone, that must be omitted between the ends of the ribs, to remain

in the surface of the compartment, and thereby reduce yet the mass of the stone by just that cut off piece of the rib.

But men went still farther, when in certain cases where the plan of the vault required no abutting or intersections of the separate ribs, when these last simply pursued their course, to indicate a stopping point by allowing a rib piece cut in the same profile at both sides to cross at right angles in Fig. 243. We have had no opportunity for a closer investigation, that exception is found in the church of S. Katherine at Eschwege. However it is not improbable that men desired to ensure a certain bonding of the ribs extending flat beneath the compartment with the masonry of the compartment by just these longer crossing pieces perhaps passing through the thickness of the compartment. These corresponded to the rib arches inserted at certain distances and the cylinders passing through the compartments in certain early Gothic churches of Westphalia, which effected a similar strengthening like the bands on the columns and little shafts of the early Gothic.

8. Springings of Vaults.

The springings are the lowest parts of vaults, so far as they are connected with walls or piers, and therefore must be executed at the same time as those, while the erection of the proper vaults only follows later, after the whole is under roof.

Dangers and securing the springings.

In the pregothic the lower ends of arches and vaults were m mostly built free in the body of the supporting masonry. Fig. 245. This arrangement is safe and good if no rising masonry r rests on the lower end of the arch, thus if the upper high wall is set back to the line n n. But on the contrary if the wall is continued above in the same thickness, it rests partly on the extrados of the arch, and there finds the unsafe bearing. When the joint between the arch and wall is open, their occurs a danger of a sinking of the wall at one side. This case can be conceived to occur in the middle walls of a basilica above the vaults of the side aisles. Still more insecure is the arrangement where above a strongly loaded pier carried up high, arches at both sides or wall arches cut in, as in Fig. 246. The heavy upper pier thrusts like a wedge driven between the arch springing, forces them apart and crushes at A the lower little stones until by continued movement destruction occurs.

In several new architectural structures have disasters occurred by this procedure. The endangered place may be secured by setting the pier and ends of the arches in good cement mortar, therebly making an entirel block of stone; also the wedge ing effect may be reduced by stepping the voussoirs (Fig. 247); but far more allowable are the logically deduced constructions introduced and tested in the middle ages.

Where it was concerned, Romanesque art sought to create relief there in the most effective way, so that the cutting of t the springings of the vaults into the masonry was avoided, the cross arches and also indeed the groins being supported by strong projections. Fig. 248. This expedient was naturally also most secure, so far as it went and Gothic also retained it.

But the projections restricted injuriously the internal space, and particularly made the aisle piers undesirably large. Men first sought a projection by strong projecting capitals, also indeed by the partial use of corbels, thus making the lower w wall thinner than above at the vaults. But this did not always suffice, and men usually saw themselves compelled to insert at least partly the springings in the wall. But they allowed now --- and that was the result of the new method of construction --- to be one with the wall. Figs. 249, 250. The beds were horizontal for the thickness of the wall, and in the projection they were either continued horizontally (see a and b in Fig. 250), or were made radial there.

The beds only continue horizontally if the face angle was n not too acute, and if sliding of the upper stones on the lower was not to be feared. But a slipping of the upper on the lower stones is possible if the angle a in Fig. 251 between the direction of the pressure in the vault and a perpendicular to the bed does not exceed the angle of repose. (Between stone and soft mortar about 30° to 45°, more for hardened mortar).

Springings of brick ribs.

The cut stones forming the springings of a cross vault are so large as to make it possible to transfer the strong thrust to the vault combined here, uniformly and quickly to a surface as large as possible on the supporting masonry. For brick it is advisable where possible to have a cut stone for the springing of the vault, but otherwise care must be taken to have hard bricksand strong mortar (recently cement or trass) with good

bonding. Particularly is good execution required where rib sections of moulded bricks are at the springing.

Let Fig. 252 be the cross section of the rib, then if Fig. 253 shows the plan of the springing of the rib, its execution is made by the omission of the part a d c of the brick cross rib and the part a b c of the brick diagonal rib and thus the lowest bricks of the under course take the form shown in the right half of the Fig. In the following course of bricks for bonding are cut in a different manner.

Rib springings composed of moulded bricks are necessary for making the joints, mostly radial in the first course, and the separate bricks then maintain their places as in walls by the adhesion of the mortar in spite of the inclined position. But where the vault was to be plastered later, and the springing was cut from ordinary bricks, it is better to corbel out the entire height in horizontal courses, or at least the lower part of the springing of the vault.

Springings of vaults without ribs.

The rules to be followed in the execution of the springings of vaults also naturally are applied to ribless vaults. The s springing is to be reckoned there to the place where the bricks of the compartment become free from the wall. If in ribless b brick vaults there exist the brick strength groins projecting above usual in them, then naturally for them the springing extends to their becoming free from the angle of the wall. The springing will best be built up to this height at the same time.

The height of the beginning of the stiffening groin is determined by laying off its cross section a g on the extension of the diagonal groin a x in the plan in Fig. 254, carrying up t the groin rib a'x' and g'i' (Fig. 254b). From the plan and erecting a vertical at a', which cuts the back of the rib at i, x, then a'i' is the height to which the springing of the vault is joined to the wall, therefore the corresponding part of the c centering must be set at the required height in constructing the wall, and on it will be built the lower spandrel of the v vault. In practice in brick vaults, especially if segmental, the springing is often not carried up at the same time, so that it must be the more carefully inserted later.

If several bays adjoin each other and are separated by cross arches, in case they bear an upper wall, these must be vaulted

at the same time with the rising masonry. When they serve only to strengthen the vault, it suffices to carry them to the height of the compartment spandrel adjoining them, so that the F Fig. 255 gives a perspective view of such a spandrel.

Springing of ribbed vault.

More complicated and differently formed are the rpringings of ribbed vaults. Already for ordinary cross vaults with projecting side arches, occur at a vault spandrel three arches at the corner of a room, five on the flat wall, and seven for a projecting angle. These arches may be turned free beside each other on an abacus slab of the capital or corbel as in the Romanesque period, or their plan may be carried sp together more or less (Fig. 257).

In the first case there is no mention of executing the springing of the ribs at the same time with the wall. It is only necessary to set the capital or corbel in erecting the wall and constructing the wall ribs together with it, while the other ribs, for whose bearing must exist the necessary space on the corbel, are then placed when the vault is to be completed. All bonding with the wall is omitted. But on the one hand this connection is essential to the safe transfer of the thrust of the vault, especially for a lonsiderable stress, and on the other the large surface occupied by the separate ribs demands a great projection from the face of the wall, which requires either the arrangement of wall piers ending beneath it or a massive and high corbelling, by which moderate or limited dimensions are obstructive. For both reasons in contrast to the Romanesque, in the spandrels of vaults in Gothic art, as a rule the plan of the ribs compines together and with the wall, first separating at the height where the ribs have allowed the space necessary horizontally.

There are chiefly two points to consider. First must the springings of the ribs be easily and properly inscribed on the s surface on which they rest. Hence their plan at bottom is first arranged according to whether a separate shaft is to be placed for each rib or a common round or corbel is set for all. In t the first case the polygonal shape of the abacus follows the plan of each separate rib, while in the other the general plan of the ribs must correspond to the form of the abacus of the capital. The second point to be considered concerns the upper

surface op the springing of the ribs and consists in this, that it is advantageous for the execution of the compartments if the outside points of the different ribs if possible are freed from each other at the same height. The fulfilment of this condition depends on the form of the bottom plan. The possibility of it is indeed given in all cases; but with an irregular plan of t the bay it is only difficult and attained by continued experiments, and the bottom plan may compel such an unsuitable shape, that it is often better to deviate from it.

The more regular is the sparation of the members and the freeing of the mouldings from each other, the more beautiful will be the appearance and the easier is the preparation of the stone.

Requirements for the regular separation.

An entirely regular separation of the arches then occurs when the following conditions are indeed satisfied.

1. All middle lines of all arches intersect in one point in the plan.

2. All angles between the directions of the arches are equal to each other.

3. All arches have the same cross sections.

4. All arches are struch with the same radius, at least in their lower parts, when all arches are not stilted at all, or are so to equal heights.

The endeavor to take these requirements into account as much as possible, has sensibly influenced the further development of the Gothic vault, and it is completely fulfilled in the fan vault. The ordinary cross vault can only unite all the points when it is executed over square bays. Fig. 257 shows the springing of the vaults at the junction of three square bays, where all the preceding conditions are satisfied.

Most vaults and especially early Gothic do not combine the above requirements in a regular treatment of the springing, indeed often having not a single one of them. Yet by skilful solutions the existing irregularities are so far reduced, that they are not geeatly disturbing. To afford the beginning for overcoming the irregularities in designing, a brief explanation of the four points mentioned may pind place here.

Intersection of the middle lines in plan. The intersection best lies in the face of the wall or its angle (Figs. 257, 260), yet frequently reasons (to be explained below) lead to placing

it farther back (Figs. 261, 265).

If the union of all directions of the arches at one point is not attained, but two or more points of intersection occur, t then the thrusts of the arches may cause an effect of rotation as shown in the plan of Fig. 258. The thrust I turns the point A in one direction and the thrust III turns the point B in the other. But unless the difference of the points A and B is not too great, this effect is not dangerous. A slight eccentricity is also not very notable in the appearance. Therefore a transfer of the point of intersection is often made intentionally to relieve other greater irregularities, as will soon be shown in Fig. 264.

2. Equal angles in plan between directions of the arches. In spite of the great advantages of equal angles in plan, they a are mostly different. This case already occurs in cross vaults over rectangular bays, as in Fig. 259 the angles a are notably larger than B. Fig. 260 shows that the upper surface of Fig. 260a is the prespective view of the corresponding springing of the vault. Ribs and cross arch separate at the same height at the points c and d, and the ribs and side arch have already separated at the much lower points m and n. Consequently the spandrels of the compartments start at different heights at t the places where the two front spandrels begin at c and d, the side ones already have the width a b or e f. These side springings of the compartments must be cut in the stone, as first begins the compartment masonry above the line a b. Structurally the beginning of the compartments at different heights presents no disadvantage, and when for sake of a good appearance a separation at the same height should be attained, relief can be obtained by setting back the intersection O to O in Fig. 261. The compartments begin at the same height at the points b c d e. On the other hand there result slight irregularities in the lower connection of the side arch with the rib in case the former does not have a suitable radius or is stilted. Likewise p pacing the point O' back too far easily has the disadvantage, that below the arches very quickly pass into the surface of the wall. For this reason it is often best to allow the start of compartments at different heights, and the perspective in Fig. 260a shows that the effect is really not so very disturbing.

Not to be avoided is the placing of the spandrels of the

compartments at different heights, where join two bays of unequal widths. Fig. 262 shows such a plan where all four angles are different. The beginnings of the spandrels of the compartments separate at different heeghts (Fig. 263), even if the middle lines of the arches all run to the point of intersection O. By a transfer of the middle lines of the arches so that they intersect in two different points O′ and O″ behind the face of the wall (Fig. 264), the three points of separation c d e are brought to the same height, but a lower beginning of a spandrel at a b is not to be avoided.

2. Similarity of the cross sections of the ribs. As mentioned in other places, like cross sections are used for some of the earliest works, but they again come into use chiefly in the later Gothic. Otherwise a difference between cross arches and ribs forms the rule.

Most regularly developed is the springing when all arches are alike (Fig. 257). Yet the influence of wider cross arches if no other difficulties occur, is very easily equalized by placing the intersection of the middle line of the arch back of o′. (Fig. 265). If the side arch is half the width of the cross arch, then the intersection o′ regularly falls in the plane of the wall.

More difficulties are produced by the compression of the cross arch and rib members on the abacus. A broader cross arch differing little from the rectangle cannot usually be contracted much below, at least the underside a b must remain the same. This fact explains why also for the cross arches, especially in the late time, a form of cross section reduced on the underside was favored, that is often shaped to entirely correspond with the arches. When the cross arch according to its internal nature is moulded differently from the rib, then care must be taken that in the combination of the members arises a beautiful intersection, of which one can judge by drawing horizontal cross sections at different heights of the springing.

4. Agreement of the radius of the arch and the stilting. A beautiful combination is easily obtained if all arches are struck with the same radius, their centres lyong in the same horizontal plane. But since requirements in the heights of the arches frequently oppose fulfolment of this law, then in many cases it cannot be carried out, particularly for elongated bays,

unless the expedieot iotriduced by English Gothic of arch lines struck with several radii is adopted. (See the preceding elevation of the arch (Fig. 48)).

Where different radii occur, usually the irregularity shown in Fig. 266 cannot be avoided. If the arch I is struck with a greater and the arch II with a smaller radius, then will II at a certain height have receded horizontally already farther than I, i.e., the back of II has already receded to the point b while the back of I is only found at a. Consequently there is formed beneath the line a b a vertical surface of the spandrel, that above a b passes into the warped surface of the compartment, whose shape is shown by the drawn joint.

Frequently a stilting of certain arches cannot be avoided, and this usually also leads to the warped form of the spandrel of the compartment represented in Fig. 266, but in a still higher degree. Particularly commonly occurs the stilting of the s side arches on elongated bays. This stilting extends to a height where the other ribs have already separated far apart, so that there results the plans in Fig. 267a to d). Characteristic of this development of the vault is the weak connection between the springing and the wall, that is limited to the same measure m n in the entire height of the stilting. Since just at this point is to be rtransferred the thrust of the vault to the wall, care must be taken for a very strong construction with large bonding cut stones or hard bricks in excellent mortar. Further at these points the compression of the members should not be carried too far, especially where two bays of unequal width exert different thrusts from both sides. An example of a particularly great stilting of the side arch is afforded by the middle aisle of S. Paul of Liege.

For narrow side aisles frequently occur the converse case, and elongated bays are formed with side arches on the longer sides with a cross arch at the end. The cross arch must then be stilted, which produces a wide form of springing, like that drawn in Fig. 268 from the early Gothic collegiate church of S. Maria at Lippstadt, and shown in an expressive way. Fig. 268a is the plan above the capital, Fig. 268b is that above the stilting, and Fig. 2681 is above the separation of the cross arch.

Particularly striking is the appearance in polygonal chapels

or choir endings. The difference in length between the sides of the polygon and the ribs is so great in the plan, that the former are mostly spanned by very highly stilted side arches. Where the stilted always rise straight, the rims are already very far removed from the wall (Fig. 266a). A particularly high stilting is shown by the side arches in the Gothic choir of the cathedral at Aix-la-Chapelle (about 1400).

Laying out the cut stone.

As for what now concerns the practical execution of this springing of the ribs, this is done in stone, so that it consists of one or more courses of cut stones laid on each other with horizontal beds. On the upper surface of the springing the separate arches may either be cut with either horizontal or radial beds. The radial position is then to be preferred for other reasons, if the horizontal beds would intersect the different arches at acute angles, as allowed by the nature of the stone. It is of the greatest importance, that the laying out of this springing is done with the greatest accuracy, so that the pieces of stone to be set thereon later shall make no bend horizontally or vertically with the members wrought on the springing. (Note). Hence the construction of these cut blocks is illustrated for the different courses in the following.

Note. In the numerous old works a careful eye can see a bend over the springing, that partly is to be referred to inaccurate execution, and also indeed partly to later crushing.

Laying out the cut stones. Example 1.

The springing of the vault consists of a cross and two diagonal arches, the widths of the bays and the radii of the different arches are equal, their centres lying in the same horizontal plane. Figs. 269, 269a.

The middle lines of the three ribs intersect at the point b, the underside of the strongly projecting members resting on t the capital or corbel as drawn. The springing must consist of one block that extends up to the separation of the ribs. It is then to lay off the height and the upper surface of the stone.

On the middle line A B as base is revolved into the plan the side elevation of the cross rib, whose inner arch a x and back is b y. The point where the ribs separate is d in the plan, and at it is erected a vertical to cut the back of the arch in e. This point e is the point of separation of the ribs in elevation.

a horizontal through e gives the height of the block, which is thus already found.

The upper bed may be entirely a horizontal surface g e h or it may be radial for the depth of the ribs e f. The beds are here assumed to be permissible as horizontal. There is now to be projected on the plan the outline of the upper bed. This is simply done by dropping verticals from the profile and determining the points m″n″ etc. on the plan, where by drawing horizontal lines through the points m n the desired points m′n′h′ are obtained. For more accurate drawing of the profile, other points may be found in the same way.

The top bed of the rib thus appears as the elongated profile d h″n′m′. For the diagonal ribs is employed the same procedure, and for example the elevation of the lower diagonal rib is revolved likewise about the line b r, etc. But it is not necessary in this case, since with the present assumption of horizontal beds of both ribs they are exactly the same as that of the cross arch, thus they are found by simply transferring.

Thus the top surface is thereby found for the three arches. Yet it appears that at this height the arches are already far removed from the wall, and therefore it is now to fill the spaces between the points s or t of the wall. That depends in the form of the side arch. In this example is no projecting section of the side arch, but only one line of the side arch is struck with the same radius as the three ribs, then while the angles of the ribs are moved back from p to s, and the side arch would be moved back from p to w. Consequently the line s w is to be drawn, which lies in the surface of the compartment. The masonry of the compartment will later be set on this line. The spandrel of the compartment below s w will also be wrought in the stone block, and is drawn down to the point p.

If the side arch is struck with a greater radius, or is somewhat stilted, then it is not set forward so far at the top of the block, at perhaps first passes from w to v (lower half of the Fig. In this case the line t u limits the cut block. But the side arch may also be stilted for the entire height of the springing. The side arch then rises at the point u, so that t u is the outline of the cut block. The springing is then made v vertical below u t, being warped above u t as shown in Fig. 267. A more accurate conclusion concerning the relation of the

side arch is thereby obtained, as it is laid down on the line n p in the plan.

On the cut block is wrought a projection anchored in the wall and as wide as the stone employed permits.

Laying out cut stones. Example 2.

2. The springing of the vault consists of a cross rib, two diagonal ribs and two side arch ribs, the width of the adjacent bays being so different that the points of separation of the ribs lie at different heights. Since further both the crowns of the vaults lie at the same height, then must the radius of the narrow bay be greater. On the contrary the crown of the s side arch must lie somewhat lower than that of the diagonal arches, so that those of the wider bay can be struck with the radius of the latter through from a point in the common base line. The side arches of the smaller bay required the same height, struck with their span as radius, and are stilted by the difference of the resulting rise and that of the greater side arch. Fig. 270 sows in the hatched portion of the plan the springing of the rib resting on a hexagonal capital.

There is drawn above the middle line of the little cross rib its side elevation and revolved about a b as base and struck with the rib a c etc.. In plan the back of the rib separates at the point e from the adjacent rib, therefore at e is drawn a perpendicular to a b that in elevation cuts the back of the arch at f. Hence g f indicates the greatest height of the spring of the rib. According as the upper joint is horizontal or radial, it will be indicated by the line f h or f h′. By projection downwadr there results for the horizontal joint the profile e k i, or for the radial joint e k w as the projection on the plan.

The side elevation of the cross arch is likewise revolved a about the line l m as a base. On the back is assumed a point that has the same height above the base as the point f from the base a b. The radial joint at this height would as before be projected on the plan, showing the profile p r x, and a horizontal upper joint as in the former case would give the longer profile p r g. Since in this case the cross arch is struck with a smaller radius than the arch, its profile at this height is projected by r e farther than the arch, and it results here that the frequently occurring spandrel explained in Fig. 266

has a warped compartment spandrel above.

In the same manner will also be found the plan profile for the other cross rib s t at the same height f g, whose back is at the point u, so that the line p u here forms the back side.

When as here the joint is made radial to avoid too acute an angle, then the stonecutter do without the accurate construction of the plan projection e k w or r p x. He needs only to project the back edges e k and p r and to transfer them to his cut block; he works from this edge a radial bed and draws on this the actual cross section of the rig.

Since at the beginning the height of the springing is fixed by the length f g, now its length and height are determined by a rectangle y z a′b′ circumscribed about the upper surface. The projection of the cut block into the wall is naturally made by a projection of the line y b′ as large as the stone permits.

If it be desired also to cut the quickly separating side rib in the same block for its entire height, the width of the stone would be increased unnecessarily. Therefore it is cut as shown in Fig. 270 by the profile being radial at the edge of the stone, on it being made a cut in which is placed the back of the first stone of the side arch. Laying out is also similar here. The elevation of the side arch is revolved about d′e′ as base, and according to the width of the stone is erected a vertical to cut the inner side of the side arch at g. From this is drawn the radial joint g′h′ and the cut for the back runs in the arch line h′i′ to the top of the block.

The side arch of the little bay is stilted by the height of the springing, and therefore shows the same plan in the upper bed of the springing of the rib as in the lower one, so that also the face of the compartment is here formed by the continuation of the radial side surface of the profile of the diagonal arch a b. Fig. 270a exhibits a view of the springing of the rib of the smaller bay. In both views (Figs. 2707, b) the points corresponding to the plan are indicated by the same letters. The side arch of the smaller bay remains, as shown by F the Figs., entirely joined to the springing of the rib and first separates above its upper arch, so that on the surface C in Fig. 270a is set the cut stone represented in Fig. 270c, and on the radial surface D of the latter are placed the succeeding pieces of the side arch, just as those of the upper ribs

are set on the radial surfaces p x r .od e w k in Fig. 270a.

The construction of the cut stone drawn in Fig. 270c is the following. One draws above the line o′d′ as base the elevation of the side arch beginning abvoe the stilting. At the point r, where the side arch projects from the surface of the compartment is erected a vertical to cut the back at s′, and then o′s′o is the height of the block and s′t′ is the radial joint. In the perspective of Fig, 270c this joint is shown as the surface u″ w″. The cut stone must bond at both sides and therefore n needs corresponding projections, as a piece u″v″ at least equal to the thickness of the compartment, by which the cut stone is held in the nucleus, and then the piece w″x by which it extends into the wall, and that naturally has the length by which the side arch bonds in the wall.

This little cut stone is set on the springing of the vault, while at the other places the ribs are directly carried up. The interval between the rib and that block is filled by the masonry of the compartment with its backing extending to 1/3 or 1/2 the height of the vault. Where greater cost is not feared, it is particularly preferable for vaults of wide span to place the lower piece of the compartment as a cut stone in Fig. 270c into a great stone represented in Fig. 270d. The three arch surfaces E F C are set behind the backs of the ribs, while the surfaces H I K L are pieces of the compartment. The surface H shows by the hatching the warped form of the springing of the compartment.

If the height of the springing of the vault is very great, then it will be divided in courses, in this example into two, as illustrated in Fig. 270a and b. The form of the joint surface is easily laid off as before, it is sketched on the corresponding bed surfaces of the cut stone, that are then cut according to the requirements of the curvature of the arches. Thus is completed the construction of the springing of the ribs.

Restriction of the basal area.

Fig. 270 has shown that the construction of the side arch w with the body of the springing of the ribs in a single cut block in some cases brings with it certain difficulties, that c can be avoided in different ways. First then by a separation of the side arch from the other ribs.

Separate springing for the side arch.

This separation results of itself when for each rib is arranged a separate shaft. Fig. 271 shows the plan of such an arrangement from the choir of the church at Wetter. The shafts here stand so far apart, that the cross rib and tte diagonal rib s spring only in the straight sides of their profile, but the s side arch lies entirely free. But aside from the easier execution also the nature of the thing is thereby more perfectly i indicated; for the function of the springings of the arches only consists in connecting the separating arches at their beginning together and with the wall. But the side arch moves in toward the wall, is directly joined to it, and therefore requires no further connection with it. Thus in all cases a correct conception and easier execution occur together, and there exists a reason against every conception and every suspicious arrangement, whose execution would be excessively difficult, and only possible by concealed means. In the present case the shafts are connected with hollows and bear capitals of hexagonal plan according to the direction of the ribs. These capitals project strongly the shaft of the side arch a in Fig. 271. up to the higher base of the side arch, ending there with a round capital. Thereby is also avoided the stilting of the arch. On the hexagonal capitals b and c of the shafts in Fig. 271 then rest the cross and diagonal ribs, whose hollows adjoin, and thus the regularity of the entire design appears more clearly. But on the shaft caliptal d stands the side arch, whose profile corresponds to the plan of the shaft; hence the capital d is also round and merely serves to indicate the springing of the arch.

In more simply executed works and in smaller dimensions is sometimes found the separation of the side arch from the other ribs placed on only one shaft and effected by very thoughtful arrangements. Such is shown by the springing of the ribs of t the choir of the church at Immenhausen dating from the beginning of the 15 th century, Figs. 272, 272a, where the stilted side arch rib is set back below, thus leavinm free the springing consisting of a cross rib and two diagonal ribs. After the side arch has been thus stopped, there yet remains the rectangular body f g h before which the springings of the other ribs are placed, and that with the same rest on the octagonal capital. In like manner the side arches in the church of S. Maria

at Heiligenstadt terminate below like corbels. Such simple me. ans contribute much to the high charm of the simplest old works, even of the later time, and distinguish them by their freshness and thoughtful invention from most modern ones.

Shortened springings. Corbellings.

Strictly taken all such shortened springings, so far as they are cut by horizontal joints, only form corbellings from the surface on which rest the ribs, and therefore may be replaced by corbels or even their work can be transferred. For static reasons strongly shortened springings require no support, since the thrust of the vault is transferred to the wall far above.

Fig. 273 shows the plan and Fig. 273. is the elevation of the springing of a rib consisting of two cut stones in height, and the hatched part of the plan gives the horizontal profile at the height of the joint a b. Hence the corbel indicated in the figure could support the upper stone, thereby raising the base of the vault the distance a c, which will be a real advantage in low rooms.

But by the arrangement the original line of the pure semicircle or pointed arch is changed into a segment of this form of arch, and thus the esthetic effect of it, the change from the vertical to the curve is destroyed. On the other hand by a complete development of the arch lines the loss of height caused is then only a disadvantage when it interferes with the placing of furniture against the wall surface concerned. Where no care is to be taken in this respect, there without injuring the effect of the whole the springing of the arches may rest on the floor. Thus it is found in the sacristy of the church at Wetter only two feet above the floor. But the wide span of the arches has the effect that at the height of a man they still project too little from the face of the wall to injure the convenience of the room. Figs. 274 and 275 show the contrast of the two arrangements.

For smalles pases a corbel is no longer necessary for structural purposes. But a simple horizontal ending is not satisfactory, since it does not show the transfer of the force to the wall, and it is better replaced by the arrangement shown in F Figs. 276 and 277. This form is recommended by its simple and cheap execution, and is generally found in old works, particularly in unimportant rooms. But it may also with advantage for

a single rib be substituted for the springing of the rib, especially if the limited plan of the capital offers no bearing f for the rib in question, so that all start with the others and must be joined to them for a considerable height. This height will be substantially reduced by an arrangement shown in Fig. 278. On some piers of the church of S. Elisabeth at Marburg is found an allied arrangement, so far as the extreme members of the ribs are corbelled instead of resting on the capital.

If it is desired to avoid by such means a too strong projection of the members, then men have not hesitated to compress together the mouldings at the height of the support, that only the bottom fillets of the profile remain free. In the vaults in the cloister at Aix-la-chapelle these fillets directly form the wall pillar without a capital. Fig. 279.

Springing at a point.

At the springing of the ribs from the face of the wall or an angle, the plan of the ribs may be conversely so far compressed at their lower bed, that their middle line springs from a point lying in the surface of the wall, so that now the ribs spring from the wall surface and may now expand from their meeting at a point, as Fig. 280 shows in elevation and Fig. 280a in plan at a larger scale. In the last Fig. the plans of the separate ribs are given in the position behind the face of the wall, t that they would have in a free development from the point a. It need not be noted that this plan does not really exist, but is first developed as the ribs separate, as the horizontal section indicates at the different heights d and e in Fig. 280. The construction of the elevation from the plan is the same as shown by Fig. 281. The entire treatment represents in a certain sense an exaggerated result of the principle of all compressed springings of ribs. But their appearance in comparison to that of one resting on a corbel or capital, a springing of a rib in correct proportion to the size of the room, is dry and wearisome, since it even removes all body from the springing.

Therefore another arrangement, likewise belonging to the late Gothic, deserves the preference, by which each of the three r ribs springs by itself from the wall, so that the points in w which they spring lie beside each other as shown by Fig. 281 in plan and Fig. 281a in elevation.

The construction of this form is as follows:- all ribs are

struck with the same radius and their starts lie at the same height. First is then above a b as base is struck the arch a c etc. through the different angles of the cross rib, and the p projections of these angles are drawn as d e and f g, and then will each of these angles be visible in the elevation, where their arches intersect the face a k of the wall, thus for example the angle d at the height a i, the angle f at the height a k, etc., from which is the outline a d f l in Fig. 281a, in which the cross rib intersects the face of the wall is already determined. Now to find the same line for diagonal ribs their different arches are then struck above the line m n as base, the projection lines of the corresponding angles are drawn, at the points where the latter intersect the face of the wall, m making vertical sketches on m n for the corresponding arches, there results the length p r as the height at which the point u comes from the face of the wall, the length s t is the height at which the point v comes from it, etc.

If we now combine the last plan of the separate ribs coming from the face of the wall with that of the corbel there results the peculiar shape shown in Figs. 282 and 282a, an arrangement occurring in the south side of the cloister of the cathedral of Erfurt, where from each rib is arranged a separate corbel set in the direction of the rib. This form makes possible a broader design of the springing od the ribs and therefore it requires a smaller height for them. Such a wider springing of the ribs may indeed be placed on a common corbel, as for example occurs in the southern aisle of the church S. Blasien in Mühlhausen, yet it is not to be mistaken in the places mentioned, that the flat shape of this corbel has no favorable effect, and is inferior to that of Erfurt.

Usually the design of a combined corbel requires an animated projection of at least half the basal form, according to which it is shaped, but five sides of the octagon are better, four or five of the hexagon, two of the triangle, etc.

Crossing of springings.

We have even called silly the design of the ribs from a point as shown in Fig 280, yet in many works of the late Gothic, men sought to go beyond this, taking this in a literal sense. For with a fixed position of the cross rib, the springings of the diagonal ribs of a bay were extended over the cross rib into

adjacent bays, so that the springing of the diagonal rib on t the right side projected to the left, and conversely that of the left to the right, so that these diagonal arches crossed the cross rib near its springing. Very beautiful springings of ribs of this kind are found in the present Catholic church in Marburg, as well as in a side room of the church S. Maria there. The first is represented in plan in Fig. 283, in front elevation in Fig. 283b, and in diagonal elevation in Fig. 283a. Therein a is the projecting shaft, b b are the diagonal ribs that cross at c, d is the cross rib, that intersects the former ate, f f the side arch ribs which intersect the diagonal ribs at g, while attached to the wall. Here indeed is scarcely longer the assertion of any development of the entire form from the construction, and an utilization of the materials, of a demonstration of the structural principle, or in brief of logic, it is first a triumph of manual skill conscious of its certainty. Y Yet we cannot refrain from wondering at the precision with which these later forms are executed. It has the same effect as when one forgets the point of view of handicraft in viewing t the artistic perfection of manual skill. And in nowise may many modern artists justly think themselves superior to the point of view of those workmen, whose works have such an extremely wise consideration nf the effect of light and of the caurse of the lines, that they still possess the advantage of actually refreshing the eyes, more than many permeated by the pure art of the modern period. We may finally regret these works of the late Gothic.

Springings of ribs over isolated piers.

In like manner to the springings of ribs from the surfaces of walls previously mentioned are found those over detached p piers, excepting that naturally the connection of the cut stones with the wall is naturally omitted. An entirely regular springing of four ribs and four diagonal ribs is shown in Fig. 284. With larger dimensions would this consist of several cut stones laid on each other instead of a single blocg. The requirements before given for the regular springing of the members have been valid here as well as the rules for laying out the cut stones.

When from a smaller area of the abacus a too great compression of the members is to be avoided, then may be arranged

corbellings according to the method practised in the before m mentioned Fig. 278.

Expansion of arches above free piers.

Yet in most cases men have not feared the expansion of the s separate arches. A beautiful example early Gothic example from the beginning of the 13 th century is afforded by the springing of the ribs above the columns of the side aisle of the choir od the Cistercian church at Walkenried, whose lower cut block is represented in Fig. 285. In spite of the different cross s sections of the cross arch and the ribs, already given in Figs. 195, 196, there is produced a salutary springing of the members. Especially skilfully cut are the nail heads on the ribs, whose sides a below join the solid surface b.

Greater difficulties arise from hre aisle piers and bases, as shown by Figs. 286 from Notre Dame in Dijon. As seen in Fig. 286a, here the upper part of the dividing arch (designated on the plan by a b c) cuts through the vertical side surface of the diagonal archmarked 1. The line followed by the intersection will be obtained as in Fig. 281 in the following way.

There is drawn in the side Fig. 286b the side elevation of the part a b c of the dividing arch, and there is laid off for each point on the plan as for example g the obliquely measured distance g h as g′h′ in the side figure. The vertical h″ gives the point i′where the angle point g leaves the side surface of the rib. From the side Fig. the intersection i′ is easily transferred to the other elevations. Likewise are yet other points of intersection obtained. The upper bed of the springing of t the arch is drawn in the plan as the outline i k l m n o.

Strengthening the beginning by carrying down the compartments

In later works the compression of the members is mostly carried still further. Where it comes to giving the pier and hence the springings of the ribs the smallest dimensions, there results at the springing a notable reduction of strength by the recession of the profile. This is avoided by filling the intervals, which is produced by extending down the surfaces of the compartments. See Figs. 287, 287a. But these parts of the compartments must be steeper in their lower parts, so that a break occurs at the height m,where the profiles of the arches become free. Above this place the compartments always lie concentrically on the backs of the arches. The arrangement represented

in the Fig. is found in the vaults of several rooms of the monastery of Haina from about the end of the 13 th century. Only the cross arch of these vaults is moulded as a rib, while the diagonal arches are merely groins.

The break in the surface of the compartment and here also in the diagonal groin would be at the height m m in Fig. 287a. Yet the diagonal arches might be formed with a true arch line, only the joining line of the compartment at the side of the cross arch forming that break. A warped surface would then form the transition. Fig. 287b.

The block obtained by extending down the compartments for t the springing is recognized in plan in Fig. 287. The area lying on the capital is limited by the outline k g l i, while o otherwise the line f g h i would be followed. Naturally also here the lower portion of the springing would be made of a single cut block.

The same arrangement would also be possible, if the diagonal arch also were formed of moulded bricks, then being cut in the same way from the mass of the springing of the ribs as in Fig. 287a.

Springing composed of vertical surfaces of the nucleus.

Besides that structural advantage, the entire arrangement has the esthetic one, that the proper function of the springing of the rib, the union of the different separate ribs in o one cut stone, i.e., of the various thrusts downward to the single piece produces a concealed appearance. It is capable of the most different variations, according to the inclination of the lower extension of the compartments. These may have a moderate connection with the greater radius, and finally may become a vertical surface. Such vertical surfaces of the nucleus as are shown by Figs. 288, 289, are found from the middle of the 14 th century down very frequently on detached piers, as well as on shafts and corbelled springings of vaults. Their origin is referred to the endeavor to beautify the mass of the springing as much as possible. The plan of the springing of the ribs is more or less accurately inscribed in some regular ground form, like the octagon in Fig. 288 as the circle in Fig. 289. In cutting the bottom surface of the stone must first be given this shape in outline. Next with regard to greater s strength the sinking of the hollows between the ribs was omitted,

rather carrying the round or polygonal nucleus vertically upward, so that a penetration of this cylinder or prism into the various lines of the arches produced animated profiles of the ribs. The same result was attained in another manner. Let there be placed the hatched portion in Fig. 289, of the springing of the ribs on a round capital or corbel; but from the edge of the capital a wash extends inward between the intersecting springings of the ribs. As the wash becomes steeper must the form become similar to that shown in Fig. 289a and entirely p pass into that as soon as the inclination of the wash becomes 90°.

The construction of the lines by which this penetration occurs is already given in Fig. 281. The entire arrangement is capable of quite varied forms according to the proportion of the sections of the ribs to the nucleus. Thus can be avoided by a greater mass of the nucleus that intersection of the adjacent ribs, for example as it occurs in Fig. 289, while conversely it appears in a greater degree with a smaller nucleus. Thus further the ribs spring from the angles of the body instead of the sides as in Fig. 288, and they may meet the nucleus vertically or obliquely (the latter is assumed for the ribs a in Fig. 289). Finally the front edge of each rib may lie in the perimeter of the nucleus or even project from this, so that the rib concerned is cut from the nucleus above the base with a s slight break. But in this also lies a means for first giving the compartment an intended direction.

For example if the compartment in Fig. 289 intersects by its p perimeter the two ribs a and d at the same angle, is indicated by the horizontal section e f, then would one or the other rib be sunk in the nucleus so far as to attain this condition.

Intersection of members of vault and of pier.

The entire system of intersection made possible by these forms is already found in the works of the early Gothic, ewen if in the form shown at first belongs to the middle period. Thus occur intersections of members of arches by the surfaces of buttresses from which they spring, further those of gable mouldings with each other already on the oldest works. But it appears that men yet laid no weight on the lines in which the penetration occurred, but allowed them to shape themselves, while in the later period they first paid attention to their charming effect, and toiled to seek, heighten and finally carry them to

excess. Caught in this excess, they lost the real structural advantages of the forms given in Figs. 287, 288, 289.

The first began to form the polygonal nucleus with concave sides, also furnished indeed with sunk panels like tracery, so that the ribs came as through a window. Or the polygon was replaced by a member harmonizing with the springing of the rib and set diagonally with it as shown in plan in Fig. 290. Instead of the regular diagonal position one was also satisfied, for the projecting parts of the ribs should come from the recessed parts of the nucleus, and conversely, so that the rounds of the ribs formed an intersection with the hollows of the nucleus and those of the nucleus with the hollows of the ribs. Such an example is shown by Fig. 291, two cross ribs and two diagonal ribs. The upper hatched portions from a to b show the plan of the pier, the part from c to h as that of a cross and a diagonal rib, the part e to f being a division rib. Fig. 291a represents the front elevation of Fig. 291 as the side elevation of this capricious treatment. The development of the elevation from the plan is substantially by the procedure shown in Fig. 281.

Intersections of this kind, particularly of the members of ribs and arches with vertical members are found in the works of late Gothic chiefly in the form, that the latter member in its extension downward forms the pier and then stops on a base. A very rich example is afforded by the church S. Columba in C Cologne. On the contrary simply corbelled springings of ribs like Fig. 289 are not well shaped in this way, since the complicated members of the nucleus must have a certain length to become intelligible.

Those with the forms of Figs. 287 to 289 are at first made possible by utilizing the mass of the cut stone, so this principle leads in many early Gothic works to more ornamental works, charming in the highest degree. For example to execute the springing of the ribs (Fig. 288a) with the given joints f′ and f″, there is required the block a b f′f″, from which the part c f′f″must be cut off. But this mass invites in form the shaping of an ornamental treatment for it, and thus the original form of the block is later allowed to appear, as well as the structure of the whole. Very beautiful examples of this kind are shown by the springings of the ribs from the choir of the

collegiate church in Wetter, on which above the capital of the shaft projected the symbols of the evangelists in the manner given in Fig. 292, from the members of the ribs. A corresponding treatment may be very well given in connection with Fig. 288a, as for example is shown in Fig. 293. Instead of the separate leaves given here might occur continuous foliage, by which the effect would be still richer. An extremely beautiful form of this kind is shown by the piers of the choir aisle of the cathedral of Auxerre before the chapel of the Virgin.(See the illustration in Viollet-le-Duc, IV, p. 149).

Here is to be mentioned the wonderful series of canopies of figures that extend around the piers of the middle aisle of t the cathedral of Milan, but they bear less the character of the springing of a vault than of an inserted independent intermediate member.

9. Masonry of the Compartments.

Material.

Natural stone.

The compartments are constructed either of natural or artificial stone (brick), and the former vary substantially according to the local geological products of the region, yet the h hard and massive stones are avoided as much as possible, occasionally are employed the different slates, and especially often limestone and sandstone. An exceptionally valued material for vaults is formed by the light tufas, the travertine of Italy, the trass from the Rhine, the widely distributed calcareous tufa, that occurs among other places near Göttingen, Mühlhausen, in France, upper Bavaria and near Paris. Good stone for vaulting was often carried to great distances in the middle ages. Besides its light weight, tufa has the peculiarity deserving consideration, that to its rough surface mortar adheres well, and that the very porous stone keeps the rooms warm and dry.

Artificial stone.(Brick).

Now the prevailing material for vaults is brick, that already in the middle ages cheated its use for vaulting purposes far outside its limited home. It is light and porous, and has the advantage of uniformity of shape well adapted to vaulting purposes, it favors freehand masonry and permits a small thickness of vaults for great spaces. The usual thickness of a half brick or 15 cm can be employed for unloaded vaults up to 10 m or moee

in span, it being assumed that compartments and ribs are correctly shaped. For natural stone the thickness of the compartments is mostly not under 20 cm, and only for especially suitable material does one go below 9 to 15 cm. An important quality of good stone for vaulting is light weight, and for this reason has been obtained a porous brick with good results, by mixing with clay a carge quantity of sawdust or of similar combustible, which after burning leaves corresponding cavities. In this way is it possible to reduce the weight one half, without lessening the strength in a notable way. For the ribs and if necessary also for the spandrels of the compartments are employed other hard burned bricks. Hollow bricks are used with a certain foresight with ever increasing favor, and in all cases one should avoid the ever feared crushing of the mortar by allowing the direction of the holes to coincide with the principal direction of the pressure. An excellent material for vaulting with moderate stresses is the light and porous pumice stone found near Andernach on the Rhine and easily prepared in dimensions of 25 × 12 and 10 cm, but it cannot be used for ribs.

Mortar.

The prevailing binding material is a good and stiff lime mortar; cement in all cases must not set too quick and is less indicated for the compartments, but it can very well give good service in strongly pressed springings of vaults. With regard to the different setting of the two kinds of mortar, it should be avoided to carry the cement mortar too high, while spreading it sidewise favors the transmission of compression to large horizontal areas. Elsewhere for strongly pressed parts lead sheets find good use in joints of cut stone ribs, as well as other materials.

Method of execution.

If exceptional forms like pot vaults and the like are omitted, then three different methods of execution are to be distinguished.

1. Concrete vaults on centering.
2. Coursed masonry on centering.
3. Coursed masonry without centering, i.e., freehand masonry.

Although all three methods are sometimes employed beside each other, there appears in general a transition from the first to the second and from this again to the third.

Concrete work.

Concrete made of stone spalls and mortar was connected with Roman traditions, but lost its importance for vaults when men earnestly proceeded at any cost to reduce the thickness of vaults. For the interior of thick vaults concrete longer retained its ancient favor.

Coursed vaults on centering.

Masonry constructed in courses on a firm centering makes known the greatest change in care and perfection of execution, and three steps can be discerned, the first being an irregular masonry that was filled with mortar. The stones were of rough shape and laid more or less in courses on the centering, either in a full bed of mortar or even dry with a later grouting of mortar on top. A more perfect step is the regular rubble vault, where stones with surfaces more or less uniform and similar are set in courses with similar mortar joints. As the highest stage is to be regarded the vaults of cut stone with sharp edges and regular joints. The more imperfect the procedure, the more the strength depends on the goodness of the mortar, but on the other hand, the more developed the execution the more can the thickness of the vault be reduced. For the last reason here again in general is also recognized an increase in the quality of t the technics; in the Romanesque period we find rude rubble vaults of great thickness, in the Gothic period better constructed and also thinner compartments. Thereby it is not stated t that there were not also Romanesque and early Christian times that were not rich in especially well executed vaults of cut stone, and as examples are mentioned only the domes of churches in western France at Periguex, etc.. Fig. 294 gives a part of the latter near the crown and very finely allows to appear the hook-shaped bonding of certain stones there employed.

Freehand vaults.

As the highest expression of the perfected technics, even if very ancient (see p. 4), appears freehand vaulting, but which is joined with a suitable material, either brick or small and easily wrought stones, whether limestone, sandstone or tufa. Therefore they are restricted to brick countries and some vicinities with suitable cut stone, and among the latter is to be placed first Isle de France, where the thickness of vaults is generally only 10 to 15 cm, according to Viollet-le-Duc. For freehand vaults the position chosen for the separate courses

are stated later in a full description.

In brick vaults almost generally a thickness of 1/2 brick or 12 cm is assumed, and this is considered as sufficient for unloaded vaults up to 10 m span, while for vaults of 10 to 14 m a thickness of the compartments of 3/4 brick made possible by special bricks is regarded as proper. On the other hand small and strongly swelled unloaded compartments may be made still thinner with a thickness of 10 cm or even of 1/4 brick. It is assumed that compartments and ribs are of statically correct form, and that the compartments are merely filling surfaces, that the ribs are the actural bearers of forces, and nothing opposes closing close meshed rib vaults of proper width by compartments of 1/4 brick in thickness. A limit of span is indicated by the stability of the ribs and not that of the compartments.

Form of compartments and pressure of vaults.

It was stated above (p. 47) that the transmission of the vault pressure in the compartment, aside from accidents, depends on the general form of the compartment and less on the courses of the compartment. Therefore a general consideration of the proper form of vaults will be made without regard to the execution, the results thereby obtained being applicable in a certain sense even to concrete vaults with mortar resisting tension.

Vaults with tensile stresses.

The very general assumption that concrete vaults can take any desired form, and that no thrust is exerted on the abutments by them, is only conditionally correct. When the concrete is fully able to receive strong tensile stresses, but only in this case can occur a certain capricious removal from the most favorable line of pressure. But the greater the difference, the greater also become the tensile stresses, and the greater must also be the resisting cross section, i.e., considerable deviations from the line of pressure require greater thickness of the vault. A concrete vault will always exhibit the least use of material when it follows the line of support. Further then by accidental stresses affecting the resistance to tension, as by changes in temperature, settlements are not in danger.

Very conceivable is the assumption that concrete vaults cause no thrust. Naturally they form a straight or vault-like slab, but however in good execution may serve as a substitute for it.

But such slabs are then to be calculated for flexure like beams, whereby results a correspondingly greater thickness, especially for a heavier loading.

Beams and vaults are quite too much confused. Beams (also the curved slab) are not fixed at their ends, produce no end thrust and are stressed by flexure (compression and tension). The vault has fixed ends, produces thrusts, and therefore is not stressed by flexure but by compression, and can be made considerably thinner.

If the curved slab of sufficient thickness be made like a great bowl and afterwards be carefully set on the abutments, no thrust is to be expected, but otherwise it occurs at once while the mortar is soft for the entire perimeter, in spite of the centering if for any reason easily appearing cracks divide the vault. Since concrete work is usually very massive, then the existing thrusts will be quite particularly large; not without reason the practical Renaissance supported the heavy vaults by very powerful abutments. Men should be warned against all too trustful use of wide and flat concrete ceilings.

Vaults with only compressile stresses.

With the scarcely elastic properties of all stone and mortar materials, it is always risky to count on their unbroken resistance, and one will not assert mysterious accidents, if he entirely forbids them to be stressed by tension. The latter point of view will also be retained here, and then the requirement will be established, that the compressile forces shall have a safe position in the interior of the compartment, that nowhere shall the compression exceed the permissible amount, and that no slipping of the different parts by the effect of compression is to be feared.

The most favorable form of compartment according to the curves of pressure is fully treated on p. 52 et seq., and in regard to the compressile stress may it be added further, that in most cases the compression occurring in unloaded compartments with their correct form remains far below the allowable limit. As the latter may be assumed for ordinary well burned bricks in lime mortar at about 7 kil per q cm, 3 to 5 kil for porous bricks, and 2 to 3 kil for Rhenish pumice stone. Hard bricks or clinkers in cement mortar can be assigned 11 or even 14 kil per q cm, to natural stones according to their hardness and

the mortar employed from 7 to 20 kil and more.

Slipping of parts on each other.

The slipping of the stones requires further explanation. When a stone exerts on its support an oblique pressure D (Fig. 295), then under some circumstances it will slip,and the easies the more obliquely the pressure acts, or in other words the greater the angle a between the direction of the perpendicular N to t the lower surface. The angle a is termed the angle of repose, and it varies much according to the nature of the surfaces of the bodies in contact. While two polished stones may perhaps slip already with an angle of 10°, the pressure of two rough stones may require an angle of 60° to 80° from the perpendicular before a slip results. For vaults a slip of one stone on another rarely comes in question, it rather concerns here the friction between mortar and stone,or just as commonly the slip of parts of the mortar on each other. Besides the rough surfaces of the stones it depends particularly on the nature of the mortar, whose resistance by friction varies between the widest limits according to the nature of its components, its mixing and quality. After settling and for moderately good mortar and moderately rough stone surfaces, the angle of repose seldom l lies under 60° or 70°, but on the contrary soft mortar shows the widest variations, when very fluid and movable, so that a slip may occur at less than 20° of inclination, and on the other hand it is possible that good stiff lime mortar makes it p possible to set a brick against a vertical wall.

For compartments vaulted freehand, whose construction is connected with the use of stiff mortar, one may usually count on an angle of repose of at least 45°. On the other hand cases h have occurred, when not yet closed compartment vaults have been caused to fall by pouring thin cement grout on the masonry. By the softening of the mortar joints the angle of repose became a minimum, and a statically unfavorable form of vault must have existed at the same time.

Location of the joints with reference to slipping.

The danger of slipping requires a consideration of the direction od the joints in section and in plan. Let Fig. 296 represent the section through a compartment or any single arch with the line of pressure drawn in, then must the angle a at the impost be not greater than the permissible angle (soft mortar be-

being assumed). When this case occurs, then the bed concerned must have a radial direction in the front part as indicated by the dotted line p q. Further the beds a b, c d etc., must not have too small an angle with the line of pressure. This possibility is scarcely to be feared with a radial portion of the beds of the vaults concerning us, and according to the measure of the angle of repose would even such beds be allowable, that converge somewhat at the top like m n or o r. Naturally will such irregularities be avoided, since the stones concerned might fall by accident without stress and without adhesion of mortar.

The same consideration is demanded by the friction of the beds of the separate courses of the vault appearing in plan, the short end joints coming in question less. The danger of slipping exists least of the joints are perpendicular to the direction of the pressure, and their position always remains ensured, if from this most favorable direction they vary less than the angle of repose.

Consequently the pressure in the vault is not affected, so long as the direction of the courses differs from a perpendicular to the direction of pressure less than the angle of repose. (In other words, so long as the angle between the direction of the pressure and the courses is not less than 90° - the angle of repose). Within these limits it is entireln indifferent how the courses may run.(see further the statements on pa 92 etc.).

If for a tunnel shaped compartment the mortar in the masonry or at least at the removal of the centering is so stiff that the angle of repose is 45°, then accordingly the angle between the courses and the axis of the vault must have this value at most. But if beds then have a greater angle as in Fig. 297, for example 60°, then would occur a movement of the courses on each other, or if this is hindered, at least a change in the pressure in regard to the abutment. For each the part A B C of the courses would load the side wall, indeed with a component K derived from the pressure D, and reduced by the resistance of friction. Certainly the force would not be very great, and the main thrust would always remain on the proper abutments. If the vaults were more hardened, so that the angle of repose was over 60°, so would the side walls be relieved even by settling or yielding, whereby the entire thrust again must be received by

lower abutment alone.

The possibility that the position of the courses produces a different distribution of pressure will most easily occur while the mortar is yet soft, and therefore it is safer for the pressure to be transmitted according to the forms of the vault, so that it is well for the courses not to vary from the pressure perpendicular to their most favorable direction by more than 45° (for greater security by only 30°) for classical vaults.

One position of the courses still needs special mention, that employed by the Byzantines and also in the later middle ages, recently again brought into honor by Möller, that at right angles to the ridge (Fig. 297, right). This especially makes easier the freehand masonry. In this the directions of the course and the pressure coincide, and each course transfers its part of the pressure to the abutment, and here naturally can occur any variation from the correct distribution of the pressure.

In most positions of the courses usual in practice no effect on the direction of the pressure by the direction of the courses is to be assumed.

Arrangement of the courses.

Position of the courses among the ancients.

If we must assume that the arrangement of courses is mostly without influence on the transmission of the pressure, yet this is the more important for convenience of execution. Therefore in this direction were made many experiments in ancient and later times. So far as the ancients constructed their vaults in complete centering, the position of the courses was of slight importance, but when men built freehand vaults, then this immediately became of particular importance.

Generally the joints in tunnel vaults as well as in cross v vaults composed of tunnel vaults formed straight lines, that in early Romanesque vaults were horizontal in some parts and in others had the same direction as the tunnel. (Compartment I in Fig. 298). When men passed to raised vaults the boints could no longer have both peculiarities together. If they remained parallel to the axis of the tunnel, they rose toward the middle; on the contrary if they remained horizontal, they took a different direction in plan (II in Fig. 298). The first kind with the same direction as the axis of the compartment was employed in Germany and in eastern France, while in the then English

France proceeded in the second way --- always including all domes in horizontal rigs usual there. The same was followed also in Normandy and in England, and it led there to the adoption of the ridge rib, and formed the basis for the method of construction usual in the later net and fan vaults. But the more or less horizontal courses also occur early in other countries. With special influence on the direction and courses was the freehand masonry, that in provinces with easily wrought small stones, and most generally acquired the mastery in brick countries. Freehand masonry required curved and short courses that men sought to attain as far as possible.

That in freehand masonry men did not adhere too closely to a previously assumed pattern, but sought to help themselves as best possible, is shown in an interesting way by the vaults in the cathedral cloister at Riga, which belong to the 13 th century. There are found directly beside each other the arrangements sketched in Fig. 299. Although the side and cross arches are pointed, the compartments are spherical surfaces whose vertices lie sidewise from the middle of the vault at the points marked by a cross. The ring-shaped courses lie about horizontal, but the closing of the compartment in almost every case has f found a different solution, since the regular annular arrangement drawn in Fig. 300 is badly carried out at an apex of the dome.

The most important positions of the courses may now be more closely examined.

Courses parallel to the ridge line.

1. courses parallel to the ridge line continued in those countries, where were large quarried stones were common until in the 15 th century, and men then vaulted without swelling on t the centering.

Most favored was the light tufa, and such was employed on h the Alexander church at Einbeck up to 60 cm long and 20 to 30 cm thick. In many provinces of Germany, for example in upper Hesse, have remained common compartments of rubble until now, the position of the courses parallel to the ridge is retained, to avoid an interlacing of oblique courses at the ridge, which is hard to execute with irregular rubble. The courses extend directly over the cross arches and join obliquely on the backs of the groin ribs.

Compartments without swelling or raising.

The simplest case occurs when the vault is neither raised n nor swelled, the joints run parallel to the ridge and are straight as in the simple tunnel vault, and it has no effect whether the compartments have a round or pointed cross section.

Freehand masonry of such a vault could only be executed for very small dimensions, for the upper steep courses must uphold themselves like straight arches, which is indeed not possible with their great length. The more pointed are the compartments the less this difficulty becomes, but still for the upper courses one could scarcely dispense with laths or planks for safe support of the upper courses, and generally the entire compartment has a centering.

If it is desired to lay out the joints, then the side arch is to be divided in equal parts according to the width of the stones, and the diagonal arches are divided in the same number of equal parts, where the lines are naturally longer. Connecting by straight lines the corresponding points gives each joint. For execution in brick or rubble no division is made beforehand, but the mason begins below with horizontal courses and continues till close to the ridge. The vault is to be executed in c cut stone, the surface is developed and the division is made on the development. (Fig. 301.

Each course extends straight and with unidorm width from the side arch. In Fig. 301 is laid off a course. Unimportant variations arise only if the projection of the cross arch differs from the side arch, for example when with a pointed side arch is employed a round groin with elliptical projection.

Compartments swelled and raised.

If a raised vault occurs with ridge rising in a straight line, then a course laid off in Fig. 302 II no longer has uniform w width, but is wider toward the groin. For swelled and not raised the course is made wider at the middle (Fig. 302 III), and the development of the surface caused in all directions is no longer possible, the compartment is both raised and swelled, thus a course is curved to the middle and also made wider to one end . Fig. 302 IV.

When the rise or swelling is unimportant, these variations for a separate course are so small as to be easily equalized by the joints. If greater, then in using bricks some of them

must be cut somewhat, on from time to time equalizing is made by a wedge-shaped course. Rubble can be sought with the necessary thickness, but cut stone with better construction must be arranged accordingly and for simplicity are fitted above on t the centering.

Pointed swelled compartments.

A particular irregularity occurs in pointed swelled compartments above at the vertex. If the courses are placed radial to the archas Fig. 303 shows in section and Fig. 304 in plan, at the top is a lenticular space to be filled by cut stones. It is closed in a somewhat irregular manner in the earlier vaults, and is more easil: completed with bricks than with rubble. In this mode of vaulting with radial joints and mostly done freehand, the joints appear as curved lines in plan. Fig. 304. Further illustrations are in Fig. 305 the internal view of a compartment and in Fig. 306 is represented the form of a widened course, and it is assumed there for more easily understanding, that the compartment forms a part of a spherical surface.

A substantially different procedure is given by Viollet-le-Duc in his Dictionary of Architecture. Vol. IV, p. 105. According to it the joints appear in plan as straight lines parallel to the ridge line. The beds are not radial planes as before, but are curved conical surfaces. For comparison this method of vaulting is compared with the former in Figs. 308 to 312.

If each course is supported until closed by a movable centering, that is best set each time under the top edge of the course to be set, then this centering will be set radially in the first method (Fig. 303, but on the contrary will always be set vertically in the method of Viollet-le-Duc (Fig. 308). Since the lengths of the courses contenually increase from below upward, Viollet-le-Duc recommends for their support two extensible planks held together by bolts and slots, that can be extended as desired. (Fig. 311). If the mason only takes care that the side of this centering is always accurately vertical, then will the joints be accurately arranged, and in each course will occur a small equalizing, since the ends are a little narrower than the middle. Thus the mason without assistance will give to each course its proper form until he comes to the middle, where a regular closing at the ridge occurs of itself. It is necessary to give to the mason nothing more than the rise of the longest

course at the ridge, or more correctly the radius of his centering, and all else then results of itself. It is recommended at the given place to construct the lower third as ordinary masonry without a centering, where the mason takes a line corresponding to each course on the centering, by laying a rod of the length of the course as a chord on the arch. A sketch is added to this explanation that shows the courses in the lower third, that have no bend upward but rather seem to have cut s sidewise. Viollet-le-Duc here makes a slight error, if the lower third is built in the way given by him, there originates w where the use of the centering begins, a lenticular opening a and a break in the direction of the compartment as shown in Fig. 310a in section and elevation. To fill this lack are here necessary small irregular blocks, that look heavy and ugly. T Therefore it must be more correct also to curve upward the lower courses, even when turned without the centering, as also assumed in elevation in Fig. 310.

If the two methods of vaulting are compared, it is obvious that in the second an advantage is to be seen, that the correct placing of the centering is easily watched and that it gives a regular solution for the crown. On the other hand the form of the bed joint is unfavorable, that in the first procedure lies in a plane, but is here a complicated and curved conical surface. The surfaces of the compartment also differ from each other; by the first construction results a spherical surface curved about the same at base and crown, while in the other case the suffface is less curved than in the former case. The surface of the intrados of each separate course has in the second case approximately the form of an obliquely ascending cylinder (Fig. 312a). It represents a course like Fig. 312. If accurately cut stones were employed, then by the first procedure results a simpler form (Fig. 307), and by the second the more inconvenient form in Fig. 313. The cut stone in Fig. 307 has only two curved surfaces, namely extrados and intrados, while the beds and joints are plane; the cut stone of Fig. 313 has only plane end joints while the beds are curved. Although no accurately cut stones were usually employed, the latter more complicated form always expressed itself still in the difficulty of giving their correct positions to the ordinary rubble or bricks.

If a compartment is to be built of bricks to be plastered later then may the centering be entirely omitted, as it can with sufficient swelling and corresponding prudence in even long courses can be turned freehand. With natural stone the centering can well be omitted, and it is advised for brick compartments on account of the regular appearance.

2. Horizontal courses of compartments.

2. Horizontal courses in compartments. The arrangement just described has the fault, that the quite long ridge courses are made rather heavy in freehand masonry. More tasteful are oblique courses as shown in plan in Fig. 298 III, that may take d different directions. Particular consideration is required by the position formed when the courses run horizontally, or more correctly if the ends of each course lie at the same height. On the ordinary cross vaults without raising this change has no effect, since the courses all terminate uniformly at the ridge horizontally (Fig. 298, compartment 9, and by a slight raising is no great advantage obtained (compartment II), the courses are only a little shorter at top, but extend in the ridge line O G with a tedious and pointed interlacing. First with a stronger raising will the horizontal courses for a simple cross vault become more tasteful, and the interlacing is more nearly rectangular. III in Fig. 298. Interlacing is entirely avoided in IV as in the vaults at Riga shown in Fig. 299. Though here the side and diagonal arches are pointed, but no angle exists at the ridge, the courses extend like the horizontal rings of a dome in regular curvature over the ridge, an arrangement that by the omission of the ridge rib is to be termed particularly tasteful, and is also to be strongly recommended for new structures with strongly raised vaults. If the swelling is moderate, the rings will be about concentric around the middle of the vault, but if it be raised very high, then in the vicinity of its crown must be a departure from the horizontal lourses, as shown by the vaults at Riga.

In many cases a prominence of the ridge line, whether as groin or hollow is not to be avoided, and then the use of a ridge rib is not only convenient for the erection, but is often required even for statical reasons. This owessits origin chiefly to the use of oblique courses.

More than for the simple cross vault have horizontal courses

a value for a rich fan or net vault, esṕecially if all their arches are struck with the same radius. In this case the courses in the plan are perpendicular to the line bisecting the angle; in plan and elevation results a similar regular form (Fig. 314), and therefore this position of the courses was generally usual for such forms of vaults.

For the smallest distance between the ribs of the fan vault can even be turned freehand compartments without swelled courses. The lower courses with their slight inclination lie safely on each other, and the upper ones evermore assume the peculiarity of straight arches. If the upper course is very short, it is allowable to turn this between the ribs, but if longer it is advisable to set a supporting prop under a course until the compartment is closed in. Such props sometimes reduce the thrust and can act as rests in need, if the considerable thrusts of the horizontal straight arches are not sufficiently in equilibrium. The last courses are to be set very firmly betwees the preceding, so that they can exert a sidewise stress on all other courses. Now if the spporting props and centerings under the ribs are removed, then in case the mortar still possesses a little ductilit:, the compressile stresses are transferred, the effect of the horizontal arches is reduced, and therefore the compartment exerts stresses from course to course. It has the form of a section of a tunnel vault and acts correspondingly. A slight settlement of the horizontal courses downward is to be expected.

Naturally here also have swelled courses their preferences before all others in the upper parts of the compartments, they cause a diffeent transfer of pressures to the ribs, but quite particularly lessen during vaulting the just described side thrust of the separate courses against the ribs. For a plain construction will also the movable centering give good service here, but men mostly omit its use and turn the courses entirely freehand.

3. Courses perpendicular to the diagonal groins.

3. Courses with bed planes perpendicular to the diagonal groins (Fig. 315) are particularly favorable for ordinary square or nearly square vaults. They have twofold advantages in the execution that they extend in a plane above the groins and that they lie close at the crown below 90°, the latter indeed only

for square vaults. The plane of the joints is perpendicular to the vertical plane of the diagonal groin and passes through t the middle of the latter. In the diagonal section (Fig. 315a) the joint plane therefore appears as a radial straight line. The separate course may be straight or swelled.

This position of the course is now the usual one in Germany, and we shall therefore show its graphical representation in t the following. Although the execution is not after such a drawing but is done according to the eye of a skilled master, and consequently there are always shown slight variations and irregularities, it follows the principle seen here.

Let a b c d in Fig. 315 be the plan if a rectangular cross vault without ribs. In Fig. 315a is drawn the diagonal section, which the here semicircular diagonal groin in actual elevation, but the two side arches are in projection, the actual form of half a side arch being given at the side. Fig. 316 represents the cross section at a smaller scale, the crowns of the side arches K and L may have the same or different heights as the middle crown C, the connecting ridge lines K C and C L may be straight or swelled. If the three points are at equal heights and the compartment courses are not swelled, the ridge lines are also straight, but otherwise are convex. If the middle of the vault lies higher than the crown of the side arch, it is simplest to draw a circular arc through the three points KCL as a ridge line. With very strongly swelled courses the ridge line is also made more convex (See C D L), so that the load of the courses here intersecting in a groin can be safely transferred. The curvature of the ridge line is also with reference to a fine development of the compartment with a certain relation to its swelled form. In any case the curvature of the ridge must not be carried too far, since otherwise an angle projecting downward might be formed in the compartment. In the present case let the ridge line be assumed as a circular arc in both directions, its projections being as given in the diagonam section of Fig. 315a.

It is next to draw the bedsof the vault. For this purpose t the division into courses is taken on the diagonal arch (for example in brick courses) and through the division points 1, n etc., are drawn radii to the centre. The prolongations 1 m, n o of these radii indicate the elevations of these beds, that even

if swelled appear as straight lines. The division points are the actual side arch at the side are easily found by horizontally transferring the points m, o, etc. to m'o', etc.

Then the division points of both arches are also to be transferred to the plan. From those points on the diagonal arch (see l, n, etc. in Fig. 315a) verticals are dropped on the ground line and the divisions thus obtained are transferred to the diagonal on the plan. Likewise are found the points m, o, etc on the plan. If the two corresponding points are joined, then are found the plan of the beds l m, n o, etc. If the joints are really straight lines, they are so in the plan, if swelled, t they will also show a slight curvature in the plan, that can be obtained by the projection of separate points. The drawing of such curved beds will not be treated further, since it is a simple problem in descriptive geometry and is useless in practice.

The construction of the other half of the compartment corresponds exactly to this, and the compartments on the right and left of the diagonal arch will naturally be unsymmetrical in rectangular vaults.

If necessary, it is not difficult to draw the projection of the springing of the vault on a plane perpendicular to the diagonal, as done in Fig. 315b. From this is obtained the revolved plan of a course in Fig. 315c, which shows the angle at the groin and allows the end joints to be drawn in. If the courses are swelled, the curvature is carried into this revolved plan, Fig. 315d, and from there can be projected back to the elevation in Fig. 315e.

Entirely in the same manner will the course of the beds and end joints be found in a cross vault with ribs, where instead of the groin edge the two side lines of the ribs are to be taken as bases.

In case accurately cut stone does not come in question, such projections of courses are mostly superfluous. When the centerings are established for the groin and edge lines or the ribs are turned in ribbed vaults, then it is only necessary to tell a skilled mason that the courses are to run perpendicular to the diagonal arches and to further inform him whether and with what rise or radius the courses are to be swelled, and he will then be able to vault the compartments correctly. Swelled courses are naturally always more favorable than straight for free-

freehand masonry.

Unequal width of course.

Figs 315 and 315a show how the bed lines diverge from the d diagonal arch in the plan and elevation, so that the separate courses increase in width toward the side arches and ridge lines. With small stresses in the vault this increase is however unimportant and is obtained in practice, partly by sorting the bricks that are never of exactly the same thickness, but partly by simply making the beds of mortar thicker toward the cross arches. If the difference in width becomes greater, then may the bricks in certain courses be cut somewhat thinner toward one end, or there can be occasionally inserted a wedge-shaped course. But cutting the bricks must be very neatly done, and entire cutting throughout must be avoided with regard to the strength of the vault.

If in extensive vaults the differences in width of the separate courses is so great, that they cannot be made with the ordinary means in masonry, then one departs from the consistent making of the beds perpendicular to the groin. There can be chosen the variations from the prescribed construction to be mentioned under 4 and 5.

But it is not stated at all, that the courses are always to be made wider toward the side arches, for even the converse m may occur. When the groin is very high but the apex of the side arch lies very low, then the projection of the latter in Fig. 317 may fall at the point n, instead of n, i.e., it can lie b below the diagonal groin. But as a further drawing soon shows, it would lead to courses which conversely diminish from the groin toward the side arches.

4. Inclined parallel courses.

Only the longest course lies in a plane perpendicular to the diagonal arch, the other courses running in parallel planes. In the diagonal section of Fig. 317 the largest bed m n is drawn radial to the centre C of the circle. On the diagonal are then divided the widths of the courses and through the division points are drawn parallels to m n. Thereby are obtained the p projections of the courses, which can be transferred to the plan or other views. The lower courses rise obliquely from the diagonal to the side arch; if the amount of rise is given to the mason for the lower courses, they by uniform widths of ma-

masonry will naturally be obtained about the direction desired for the long courses. For simple cases it will be unnecessary to lay off the direction of the beds in the drawing, the lower courses approximately rise rather obliquely from the diagonal groin and the compartments are built with courses of equal breadth to the middle, a moderate swelling being given ho the courses.

5. Perpendicular parallel courses.

All courses are parallel in plan and are perpendicular to the diagonal. In the diagonal section are no longer radial joints, but they are all represented by parallel lines.

Let Fig. 318 be the plan and a part of a vault with ribs, so that a is the cross rib, b b′ shows the diagonal rib and c c the side arch. Now in Fig. 318a is drawn the elevation of the diagonal arch which also represents the elevation of the cross arch, if it is assumed that both are struck with the same radius. The diagonal arch is now executed to the height e, so that it is intersected by the radial line e f′. Over the point d on the plan, that has the same name in both Figs., the ribs separate from each other. Thus the point of separation lies in the vertical erected at d and consequently is at d′. Here may the beds of the springing of the ribs lie still horizontal, a and hence are cut obliquely by the arches as shown by d′d′. F From e is laid off downward on the back of the arch the divisions for the separate compartment courses according to the thickness of the bricks, and then the projections of these division points are transferred to the horizontals e f as f 1, 2, etc. In the plan these points are laid off forward from the p point d on the diagonal arches, and accordingly the beds are drawn perpendicular to the direction of these arches, so that they intersect the cross arches.

Accordingly the elevation of the part of the vault can be formed that Fig. 318b represents, where one diagonal rib is shown in front elevation and the cross rib is in oblique projection.

Indeed a very slight swelling results in this arrangement naturally for each course of the compartment, if each line is a straight one on the compartment. This may be more fully explained. The extreme bed in Fig. 318 goes from e to h. While t then the point e also lies at e in Fig. 318a, the point h lies

there on the cross arch similar to the diagonal and farther b back at h. If the horizontal lines on the compartment are always to be straight, then the projection of the rising beds in Fig. 318a is the curved line e h. The swelling of this is distributed over the entire length of the bed and accordingly is extremely small. The Fig. shows at the same time, that the course in question rises from the diagonal arch to the cross arch, indeed by the difference in height of the points e and h. According to the first construction shown in Fig. 315 this rise was smaller. Above the ridge of the cross arch ever becomes less and at last entirely disappears. If the courses of the c compartment are made straight, which is however possible, then will the horisontal lines on the compartment show a slight ugly curvature inward. By the use of compartments with a stronger intentional swelling, these will best be set off upward, w whereby according to the method recommended by Viollet-le-Duc a vertical movable centering can be used.

Summary of the positions of the courses.

In the preceding are described five different arraggements of the courses, that are all jestifiable, and which is to be chosen is to be decided only in the case. To make the differences clearly prominent, they are placed beside each other in diagonal section in Fig. 319 for comparison. 1, shows courses parallel to the ridge of the compartment; 2, horizontal courses; 3, radial courses perpendicular to the groin; 4, parallel courses in oblique direction; 5, same in perpendicular direction. For completeness is added the arrangement 6, in which the courses lie perpendicular to the groin, to the cross arch, and to the ridge, and join in the middle of the compartment or interlace there.

Intersection of the courses of the compartment.

On vaults with projecting cross and rib arches whose backs are furnished by a projection entering the compartment, the courses do not join together generally but simply intersect against the projection (Fig. 320). The stones are to be cut so that they fit well. The direction of the courses is almost immaterial, and there is little value in making them perpend--icular to the diagonal, the junction at the ridge line at the most is considered, except that the existence of the ridge rib.

Intersection.

It is otherwise with arches whose section without projection at back lies beneath the compartments, for here the courses intersect over the arch.and their mutual directions are therefore of importance. If the solution described above and so much employed exists, where the courses cross the diagonal arches, h here one course goes directly into the other, but an intersection occurs on the cross arch, that by a rectangular cut is formed like Fig. 321 or 322, but with an oblique cut the bricks require cutting, while in unsymmetrical meeting as in Fig. 323 o occur offsets in the intersection. A junction exists at the r ridge line as shown in perspective in Fig. 325.

On the back of the diagonal arch the two arches belonging to the different bays lap most simply as in Fig. 324a, and therefore the springings of both arches must be cut separately and consequently weakened thereby. Hence it is advisable for great spans to seek a strengthening of the bond in such places, which is effected most easily in the way shown by g′ in the perspective of Fig. 324, so that both arches close alternately with a stretcher k and begin with a header l. On the back of the diagonal rib must be cut the separate bricks to obtain the same form of joining. But this cutting will be reduced if the backs of the ribs have the form shown in Fig. 324b.

On the back of the cross arch a in Fig. 318 meet the continuous courses of the compartments passing over both diagonal ribs b and b′ and are cut to the line m n o p. Hence when the separate vault bricks can no longer overlap, the position of each separate course is secured. But since the separate arches sink from m to g in Fig. 318b, and further each course has a bearing in the one next beneath, the adhesion of good mortar suffices to hold the brick at m in its place. A corresponding strengthening as the diagonal rib has by the brick l can also be received by the cross rib according to Fig. 324, when begun with bricks standing on edge.

Just conversely is the junction of courses when parallel to the ridge of the vault, as they then cross the cross arches a and intersect on the diagonal arches; the intersection at the ridge entirely disappears.

Vaults without ribs.

The erection of vaults without ribs occurs in the same way as for ribbed vaults, but here the construction of the groin

angles requires still more care. In rubble vaults of the early middle ages the construction of the groin was always a rather a miracle. In careful execution were employed at the groin stones more or less cut to fit. Men frequently were satisfied m merely by angle headers, but otherwise the stones were allowed to meet with a joint at the angle. But the neglect of a supporting angle was conceivable, and its heavy construction contributed a good part to the introduction of the supporting and projecting rib arches. But moreover in the entire middle ages and especially in secular art were also executed many vaults without ribs, as also they have again found extended use in wooden buildings.

But in them the strengthening of the diagonal arch shown at l in Fig. 324 became a necessity, so that the bond was made entirely according to Fig. 318b, differing from this Fig. only in that the section of the rib is omitted, and on the contrary the triangle g r s cut off the brick z in Fig. 318b remains. But then this brick does not retain its rectangular shape, but it must be cut more obtuse nearer the ridge of the vault.

Cell (cloister) vaults.

Meanwhile that this cutting may also be avoided, there originated those native vaults particularly in the Baltic provinces, yet as a rule in cross vaults, but the cell vaults arranged according to a more complicated system, which are so formed that the groin angle shows a right angle in every section made perpendicular to it. Fig. 326b.

Between the groin angles that mostly represent rich star or net forms, the compartments rise like small pyramids or high troughs. The beds lie in a plane perpendicular to the arch (radial) and form a right angle at the groin, that makes possible a simple brick bond (Fig. 326c). Usually the beds lie symmetrically to a plane perpendicular to the groin, so that then form at each side an angle of 45° with this plane.

On the last assumption is based the construction of the beds shown in Figs. 326 and 326a. For simplicity is assumed an ordinary cross vault and straight beds.

On the revolved arch is first made a division for setting the bricks on it. Through the different points of the arch above a b are drawn radii of any lengths, and these are intersected by a concentric arch at any distance a b, and on ab are

drawn the line 1 1 parallel to a b at the same distance, the division points are then projected down on a b, which on the concentric are cut by the radii on 1 1, forming the points found on a b and 1 1, so that the ground projections of the beds of a portion of a compartment are found. Likewise are obtained thusefor the adjacent portion of the compartment, whereby the intersections above a d are also found.

Fig. 326. then shows the cross section of Fig. 326. It is n next to determine in this section the height of the point d as well as the location of the point f" of the diagonal arch in Fig. 326. Through the latter is drawn the radius and thereon is laid off the distance of the point d in plan from the line a C as f"i. The distance of the point d from C̄ is laid off in Fig. 326. from C to d′, a perpendicular is erected at the latter and then is laid off the height of the point i above a C, when the height of the point d and the position of the bed d′f′are found in d′f′. Likewise are all the other beds obtained, for example those of the beds i h k as i′h′k′. The beds obtained then determine of themselves the concave angle and the intersection therein.

On the laying off of a cell vault found in Cracow, see the study by G. Bizanz in Allg.Bauz. 1888. Vienna.

Fig. 326a shows how the point d rises high above the crown of the diagonal arch, so that a considerable loss of height occurs in general. This is lessened in a way, if the faces of the compartment rise from the diagonal arch rise in curved instead of straight lines. Such a vault then differs from the cross vaults shown above with flat swelling only in this, that here the segmental arch of the swelling is replaced by a broken pointed arch, that may also pass into a quadrant.

Yet for any considerable span the introduction of this curved line will however reduce insufficiently the loss of height, and only in the reduction in the size of the panels, i.e., in an increase in the curved lines dividing the ground surfaces, is to be found an effective means. Also there results thereby the transition from the plan if the cross vault to that of the star or net vault. But even retaining the cross vault the panels become smaller and the heights are reduced as shown in the perspective of Fig. 326b, as soon as also the ridge line is formed as a groin arch, which is then built like the others forming

a rect.ngular angle, whereby the entire plan is then divided in eight compartments.

The preference for smaller compartments is explained also, that with great compartments the beds would be too divergent.

A very substantial difference of this cell vault from the ordinary cross vault without ribs appears in the proportions of the cross arches where several bays join. While in the cloister vaults the cross arches may also be formed as groins, in which the compartments regularly intersect each other, this intersection occurs in other vaults without ribs by the intersection of the courses. The uneveness this makes, especially in vaults not plastered, causes it to be desirable to conceal by a projecting cross arch, on the back of which is made the junction of the courses. The arrangement of this cross arch is very common in works of secular architecture, where the vault w without ribs chiefly finds its place, where in an upper story are required walls placed on it, whose location is then determined by the division of the bays of the vault.

10. Centerings and Erection.

Preparation of the centerings for arches.

Centerings are called the wooden forms, whose backs are intended to support the vault ribs during the construction. Their manual construction is done in various ways. Here will be given briefly only some of those most common.

1. They can be formed like a pair of rafters and the tie in Fig. 327a, on the backs of which are either cut or placed the curve. Simpler is the construction employed in upper Hesse shown in Fig. 327, by which short struts a b of different lengths and each corresponding to an ordinate of the curve are set on the rafters. These struts are cut off exactly at the line of the curve and then covered by a strip nailed on, on the back of which the rib is built or set. If the span is considerable, exceeding 8 m, then must the rafters be further connected by a second tie, or for yet greater spans have a king post, a tie and two struts.

2. The centering can also be composed like a timber arch of doubled or tripled pieces of planks nailed together, whose back is cut to the reqsired curve. Fig. 327b. In such arches with a heavy load the lower ends (in spite of contrary assumptions) tend to separate from each other to a certain degree. By this

can be produced an elastic setting of the middle in vaulting desired in certain circumstances. If a firm centering is wished, then the lower ends are to be held by strong ties, and besides is recommended a sufficient bracing to prevent deflections at the sides.

Which construction is preferable must be decided by circumstances. If the cost of material be least for the latter, on the contrary the cost of labor is greater, and the planks nailed together are later usable only for the most subordinate purposes, while the timbers framed as in Fig. 327 can always be readily used again.

Erection of centering.

The erection of the centerings first occurs when the vaults are to be closed, thus after the erection of the walls. Since now the springings of the ribs are to be undertaken at the same time with the walls, or are set if consisting of one or more cut stones, a centering is only needed from the upper bed of this springingof the rib joined with the wall as in Fig. 327. Since further the side and cross arches, if they have to bear upper masonry, are likewise already constructed with the wall, thus is needed for the erection of the vault proper centerings only for the cross arches and for other arches exclusively connected with the vault. The erectioo is on the basis of continuous purlins d, which are tied together by the transverse beams e in width. These beams are supported by posts h from which braces f support the purlins d. The transverse beams can only be placed beneath the middle lines of the bay, so that the upper ends of the groin centerings can be set on the struts g, which are again supported by a post h standing on the ground.

As shown in Fig. 327, all posts are set on wedges i, so that when the vault is closed only the wedges are driven out to permit the centering to sink, thus avoidind any shaking of the f freshly built vault.

Besides the ties given in Fig. 327a but omitted in Fig. 327, the separate frames may be held together by longitudinal timbers like purlins, that have notches for the rafters and are supported by struts from the posts g or beams e.

Certain modifications in the centerings are necessary for t the keystones usually extending below the underside of the rib, and necessary space must be left for them. In the construction

of Fig. 327 the short struts may be omitted where timber arches are cut to the curve at top. If their ends are weakened too m much somewhat deeper blocks may be spiked on them.

Otherwise is constructed the centering with the use of a fixed post. Where in Fig. 327 the middle support g (or h) is set on wedges, a through and firmly supported timber is arranged. this does not extend quite up to the keystone, so that it cannot hand on that when the centering is removed. The centering does not extend through above, but for each branch of the rib consist of a separate timber, whose upper end must be so fastened, that it can slide lown on the beam when removed. Each p pair of opposite rafters can be fastened together above and b below by ties including the timber. The lower ends of the rafters are most simply set on wedges, while the framework with the purlins d and their braces can be firmly constructed and be well utilized for the support of the scaffold for masonry.

Better than wedges, which even by careful removal of the centering easily produce shocks, are here as for other centerings sand pots or sacks, that by the correspondingly regulated escape of the sand make possible a quiet and regular settlement of the framework.

Vaulting is first undertaken when the building is brought under roof, only the springings are earlier executed at the same time as the walls. These consist of previously designed cut s stones, so that their erection presents no difficulty. For springings of brick are placed corresponding pieces of centering, not for support but as guides. In some circumstances it can be recommended to establish the final centerings, which remain in place until the later vaulting.

If springings of brick for any reason are not carried up at first, it would be conceivable that these might be erected later without bond of a small base with the wall. Then is rather made a correspondingly large recess in the masonry, which is set at the same time with the springing. The same is true for the later addition of cross vaults in old buildings.

Turning the ribs.

In constructions in brick at least three, in rubble even more (all if possible) adjacent compartments are to be centered at the same time, the vaulting of the compartments is to be carried up with regular breaks, and the centering of a finished bay

is again employed for one to be executed. After the centering is ready the construction of the ribs is first done. If they are of cut stone, the keystone will be set in place by plumbing down, and with these beginnings of the ribs it rests best on the corresponding ends of the centering. That the reb may be straight in plan a line is stretched on it and as many points are plumbed down from this, so that on the back of the rib may be accurately sketched. It is also advisable to sketch a line at one side of the rib which runs obliquely from the keystone to the springing. The sides of the rib are plumbed from this line, whereby at the same time is given supervision that the rib is not tipped sidewise. The cut stones of the ribs have a length of 1/2 to 1 m, they are set with cement, gypsum or lead sheets, and sometimes are connected by dowels or pins. The last may be made of iron, but copper, bronze or brass are better. Of the last material suffice pins of finger length and diameter, but best are brass tubes 2 to 3 cm diameter and 6 to 9 cm long. Dowels are first fixed in the upper piece of the rib and then slid into the lower piece in setting. If the last piece is doweled to the keystone, there is required a small art clamp with a string to its middle, that is entirely slid into the keystone and pulled halfway out after setting the rib.

Brick ribs may first be trussed separately like cut stone r ribs, but it is preferable to carry up brick ribs together with the compartments.

Vaulting the compartments.

The compartments are now to be vaulted freehand according to one of the positions of courses given in the preceding Chapter, so that the separate compartments are carried up together, a stiff lime mortar and very sharp sand being employed. If the mason employs no centering for the swelled courses, a sure eye is of value, and all humps that are easily recognized with later work must be rebuilt at once. In the ridge line in which the courses intersect is chiefly placed a centering. In closing one of the masons usually creeps through the middle of the vault to set the last courses from above. So that the compartments have a uniform shape, it is not advisable to employ too m many masons on the same vault, and on the other hand it is not favorable to the compressile stress to allow to occur too many interruptions for over night; on a great vault it is usual for

eight masons to be engaged at the same time. After the closing of the vault, a thin lime or cement mixture is poured over its upper surface so that the beds may not soften.

The centering remains under the ribs unchanged during the v vaulting of the compartments. Ribs of large cut stones are so rigid from their previously thin and strong cast joints, that their settlement and crushing is hardly worth mentioning, and the centering remains under them chiefly with regard to the considerable change of loading while the compartments are closed, for which the ribs are not calculated. After the completion of the compartments, nothing opposes the immediate removal of the centerings for cut stone ribs, yet they are mostly allowed to stand for some days.

For brick ribs it is advisable to leave the centerings somewhat longer, for otherwise aside from accidents the ccompressions will become so great as to be perceptible to the eye. Hase recommends 4 to 7 days according to the mortar used before removal, and in a wet late harvest to wait even 14 days.

It will be frequently observed, that after partial covering of the compartments a movement occurs in the ribs, so that their upper ends with the keystone rises from the support. This especially occurs with a yielding centering and is a natural consequence of the lacking load at the middle at first, and when this is added the keystone rises. But such great movements of the ribs are undesirable and should be prevented. This can be done by a careful propping of the keystone against the framework of the roof, but far better by a loading for which the bricks necessary for the compartments afford the natural means, and they may act directly on the keystone or be piled on planks enclosing it, indeed at first in an amount increasing with the increased height of the compartment. For the s same reasons can it be recommended to add heavy stepped backing. That the backing necessary for static reasons in the lower part is to be firmly bonded therewith and is to be carefully built in the layers added somewhat later, and not carelessly piled in is also emphasized here. A correct balancing of pendentive and crown loads will be considered already in vaulting. There appear broken joints after removal of the centerings, a and these usually warn one to regulate one of the two loads, which is to be effected according to the points of view stated

in Chapter V (Figs. 124 to 127). Slender pointed vaults are usually separated only so late from the resisting wall, that they require no backing of the spandrels.

The keystones of church vaults are frequently perforated, e either for exit of air or for fastening chandeliers, with ref-erence to occasional lowering by suspension ropes. For the lat-ter purpose also the compartments are often each perforated by a built-in tube of stone or metal, which is generally conceal-ed by gilded stars suspended by copper or brass wires.

A protection of the vaults against injuries by water, which may arise from leaky church roofs seems worthy of mention. The upper surfaces of the compartments are made smooth so that the water rapidly collects in the spandrels by gutters plastered in cement, from their lowest part a channel leads to the exte-rior or a pipe through a vault conducts to the interior of the church. The latter is best made of lead pipe at least 3 cm cl-ear diameter, and projects sufficiently far that occasional dripping of water is permitted. Naturally this means is usel-ess as soon as the spandrel carelessly becomes a collecting place for dirt. The ancients in a way worthy of imitation oft-en made the spandrels of their vaults accessible for better oversight, when they constructed the backs of ribs in the form of small stairs.

II. FORM AND STRENGTH OF ABUTMENTS.

1. General Form of Abutments.

Plan of buttress walls.

Simple solid walls.

As the nearest form of abutment for tunnel vaults and domes is presented the simple solid wall, and therefore it was enti-rely natural for men to take this first and also to retain for other forms of vaults, for example the cross vault. But solid walls require for great spans and height of abutments such an enormous quantity of building materials, that even at this po-int the not penurious Romas began to think of economy. More c consciously occurred the mastery of mass in Byzantine art, and it became the dominating endeavor in Romanesque and its comple-tion was attained in the Gothic period.

Subdivided wall.

Already for the simple tunnel vault the continuous solid wall is notthe best abutment even if the nearest. The building mat-

materials are already lessened by leaving large openings in t the wall (Fig. 329). The mass saved in such wise needs to be but partly used for thicker walls in order to restore their original resistance; for the power of resistance of a wall is to its length in a simple ratio, but for its thickness in its square. Yet more is attained by projecting piers, that allow a considerable thinning od the wall proper (Fig. 330). Finally the wall can be reduced to the minimum mass if it extends in arched form between the projections (Fig. 331), a form recently employed generally for retaining walls against the likewise continuous pressure of the ground. The transfer of the uniformly distributed thrust to separate piers is clearly expressed in the arched form of wall, but instead of a straight intermediate wall (Fig. 330), a straight arch must have a similar effect.

To such a control of the mass in plan can be added a similar one in elevation, when the masonry is not carried up in uniform thickness, but is distributed according to the course of pressure.

Thereby for the tunnel vault in place of the solid wall are found far more favorable forms, which certainly make rather t the impression of restraint and not of one derived from the p peculiarities of the vault. It is otherwise with the cross vault, for this directly produces changes as represented in Figs. 333 to 335. The thrust of the cross vault acts principally at certain points and requires its resistance at those points. T The parts lying between them can be reduced to enclosing the room, or if this problem is lacking may even be entirely wanting. For raised cross vaults must one indeed count on a greater part of the thrust falling on the wall, and this can only be transmitted downward and also sidewise to the buttresses, whereby again the curved plan in Fig. 335 presents advantages. But even under elevated vaults can the walls be opened so far as the thrust may be received by sufficiently powerful side arches. Such a side arch would contain a curved line of support in plan and elevation, which by the most difficult following of the curve of pressure would load again to the same result, to employ also a horizontally curved side arch after the form of Fig. 335.

The natural abutment for the cross vault is the divided and not the solid wall. Yet if men are left to employ the latter it is to be thought, that the parts next the springing can be

projected, and the more the wall is thinner, and therefore one can count with safety on a certain part of the length of the wall, perhaps half for average thickness, as a resistant mass. If the middle of the side wall is opened by great openings for doors or windows, this portion of itself is omitted as a buttress, just as in such a case the cross vault with right is opposed to the tunnel vault.

For a continuous abutment wall without important openings m may even the tunnel vault be preferable, aside from architectural respects, that will often decide for the cross vault on account of the freer development of the wall.

Buttresses outside or inside.

Commonly the supporting projections of the wall or buttresses lie outside the wall (Fig. 336), but nothing opposes moving t them toward the interior of the room (Fig. 337), or they may entirely inside it (Figs. 338, 339). In this case a wide side arch extends from one projection to another, a tunnel vault or an elongated cross vault. If the projections extend far into the room, they may afford opportunity for the formation of little chapels, connected with each other by openings. Finally by further opening can they attain the character of narrow side aisles.

As will be shown later, it is preferable to move the heavy mass of the abutment toward the interior as much as possible, for in this respect an enclosing wall moved outward is less f favorable. It can be proved useful so far as the desired spreading of the ground area of the buttress is brought to its outer edge. It is advisable for a wall lying outside to lead the upper loads to them less than to the internal abutments, so far as this can be done under the conditions. Under some circumstances a formal buttress system can be arranged in the interior of the church.

Elevation of the abutment walls and buttresses.

Resistance of abutment.

As stated, a solid wall requires a proportionally great abutment mass, that is true especially if no top load is on it. A Aside from accidental stresses by wind and the like, only three forces act on such a wall. 1, the weight G of the wall itself acting through its centre of gravity (Fig. 340). 2, the equal vertical resistance V opposed to the weight of the part of the

vault (half the vault) supported by the abutment. 3, the horizontal thrust H. of the vault.

The thrust H tends to rotate the body of the wall about the angle A or tip it over. The danger of overturning increases w with the amagnitude of the thrust H and with its height. The product H × b (force by lever arm) is termed the overturning moment. The overthrow is opposed by the vertical loads G and V. The greater are these and the greater their distances from the angle A (their lever arms), the more favorably they act. S Since these forces ensure the resistance and stability of the wall, the products of the force by the lever arm are termed t their moment of stability (resistance).

That the wall may stand the sum of all moments of resistance must be greater than the algebraic sum of all overturning moments. In the present case there must be; Gg + Vv be greater t than Hh. If this condition is not satisfied, the wall will then overturn. It will be later explained, that still other conditions come in question, for example that the pressure on the b building material must not be too great.

From the requirements for stability directly result the most important requirements for the form of the abutment. The point of application of the horizontal thrust is to be kept as low as possible and the thrust is to be made as small as possible, which is especially attained by light and steep vaults. On the other hand it is of value to make the vertical forces as great as possible and to place them the farthest possible from the outer angle.

The resisting weight can be increased by the use of a heavy material, its lever arm by external stepping or battering. The weight of the vault itself increases the stability, yet as a rule it must be kept as small as possible, since the unfavorable thrust increases with it. At most can a heavy backing of the spandrels come in consideration as useful.

Effect of top loads.

Of the greatest effect can be a rightly applied top load on the wall, which is itself more efficient, the larger it is and also its lever arm.

One must not depend too much on the loading effect of a roof construction, beam ceiling or even a paneled partition. Aside from the variations in weight, for the usual location on a long

plate is hard to assume that the pressure is uniformly distributed everywhere, and it is quite conceivable that just above the springing of the vault the woodwork does not rest on it, so that the wall can yield without hindrance. Besides there easily occurs a temporary lack of such construction during repairs, while rebuilding or in conflagrations.

As a useful top load on the other hand may be a solid wall, yet this depends much on its position. Its centre of gravity must be as far as possible back from the outside angle of the resisting wall (Fig. 342). If a thin and heavy wall is placed at the outer face of the wall (Fig. 341), the moment of stability will then be increased but little, while on the contrary the compression on the outer side may be increased very unfavorably. Even when in the course of time a certain leaning outward appears, the centre of gravity may be mysteriously near the outside angle.

On old works the abutment walls without buttresses have often yielded considerably, particularly of the original conditions of loading have changed, which can frequently be observed in churches without piers and monasteries. As an example are mentioned the vaults in the cathedral cloister at Riga (Fig. 341). Although the vaults are favorably constructed, their springings lying close above the ground and the widths thickness of the abutments amounts to nearly a third of the span, according to the evidence of statical results the walls are at the limit of stability. Here the raising of the upper floor and the addition of other injurious loads have had this result.

It follows from these considerations that a solid continuous wall can only be recommended as an abutment for vaults, and p particularly cross vaults where only small thrusts occur, favorable top loads exist and for other reasons thick and solid walls are already required, for example in cellars or lower s stories of high houses. In other cases the arrangement of buttresses will always lead to great economy of materials.

Elevation of buttress.

Since the resistance of a buttress increases according to t the square of its width or simply as its thickness, it seems advisable to make it as thin and wide as possible. But the limits will be fixed by the possible difference of the thrusts in the two adjacent vaulted bays, by the danger of sidewise

overturn or bending, and finally by the fact, that elongated development in plan a good distribution of the pressure on the cross section is doubtful and accordingly shearing is to be feared. Usually the width varies between twice and thrice the thickness, when the portion extending through the wall is taken with the width. It will be generally recommended to make the buttress project as thick as the wall, its projection from that being as great as the diagonal of a square constructed w with the thickness of the wall; but it should be noted, that too rigid rules for the dimensions of such parts of the building are idle and were unknown to the early middle ages.

A buttress may dominate or be subordinate to the wall, and accordingly is arranged its importance as a resisting body, b but the greater problem chiefly falls to the buttress. If the wall is only thin, then its entire length is not reckoned with the buttress as an abutment, but only the adjacent parts, perhaps at each side a square piece of wall of its thickness (Fig. 344). If the wall is yet thinner, it is advisable to count not at all on its aid, or at most to apportion to it for high vaults the thrust from the corresponding parts of the compartments.

In the elevation the buttress may rise to the springing of the vault, to the main cornice or still higher, it can extend straight up or have offsets at front and sides, finally may a also have continual changes of cross section.

The theoretically best form will a buttress have, when it exactly follows the line of support (Fig. 343). This will always lie in the middle and the cross section gradually increases downward according to the increase in compression. Whether the beds are made perpendicular to the direction of the pressure or merely horizontal is mostly almost immaterial. The internal part C D E of the wall could be entirely omitted, as far as it is unnecessary to keep the pier upright before the addition of the vaults.

In fact the buttresses on old works approximate quite near this ground form, that naturalln does not appear so directly in consequence of the entire architectural development. Even the defects of the lower superfluous part C D E are compensated by gradually corbelling out the members of the vault. Such piers are naturally constructed with the theoretically least use of materials, but require a rather deep extension in the

direction of the thrust. If this be limited, there remains nothing further than piling up a greater mass in the direction of the height.

The straight piers of the first Gothic hawe no great thickness but required quite a large mass (Fig. 344). The trapezoidal pier (Fig. 345) is somewhat thicker in plan, but saves little in mass. Instead of the trapezoid might be considered a triangular projection of the pier, especially when the enclosing walls are already quite strong (Fig. 346). The trapezoidal or triangular outline need not appear in its plain form, as it can rather have a suitable solution, when too abrupt changes in cross section are to be warned against, which of themselves easily lead to cracks and sliding.

The advantage of the pier diminished upward in Figs. 345,346, against theat of Fig. 344 are recognized by a comparison with that of the form of Fig. 343, but it also results more clearly as soon as the moment of stability shows, that the wide distance of the centre of gravity behind the angle of rotation is of advantage. In this respect yet more can be attained if the rectangular cross section is abandoned and for it are introduced different cross sections below and above, for example two triangles reversed to each other (Fig. 348). It is favorable below to make the dangerous external side a b as long as possible, but it is better at top to move the mass back as far as possible. Even this advantage the middle ages did not neglect, There frequently occur plans like that of Fig. 349, where the exteroal angles are strengthened by angular projections, while heavy finials at top close to the face of the wall load it in the most favorable manner. It is evident that the possibility of manifold treatment was lacking to the buttress in neither static nor architectural respects, but its further development will be treated elsewhere.

In Fig. 343 was it shown, that a space beneath the buttress could be entirely omitted, particularly notable for very high piers. A further advance and according to Fig. 347 the forces acting at the springings of the vault were resolved in two directions. One component in a pier A E could pass vertically downward, the other consisting of the thrust and also any part of the vertical loads was carried down following the line of support in a curved mass of masonry A C. The latter becomes

thinner but projects farther outward than the buttress (Fig. 343). The space C E between the outer and inner piers could be taken inside the building, whereby also in this way was developed the basilican church plan with its buttress system. According to the manner in which the forces are distributed to the two masses of masonry, and the mode of arrangecent in them men were able to deduce the most diverse forms for such a buttress system. How the condition of equilibrium in these can be tested will soon be described in a special Section.

Middle pier.

Thrust equal on all sides.

If vaults occur beside each other in several rows, middle p piers will become necessary for their support. Utilization of the interior demands for them generally as small dimensions as possible , to obtain which equilibrium in the thrusts from all sides contributes most efficiently. If all horizontal thrusts are mutually neutralized, the pier only requires to be so large, that under the load of the vaults resting on it, it will be neither crushed nor bent, but it would usually have only a very small cross section, which for safety with regard to accidental oblique or unequal pressures during the process of vaulting are somewhat increased.

If a wide hall or a church with several aisles was covered by vaults of equal dimensions and height, then naturally resulted gènerally an equilibrium of the thrusts, but such could also be covered by adjacent vaults of unequal adjoining spans, for example in a church with aisles of unequal widths, yet it might be attained in part or entirely by suitable construction.

Equilibrium of thrusts of vaults of different spans.

If there adjoin two vaults of equal thickness and heights b but of different spans, then the thrusts are very different, being related about as the squares of the spans (Fig. 350). With the ratio of 2 to 3 for the spans, for example the thrusts will be as 4 to 9, and with a difference of 1 to 2, the larger thrust would be 4 times the smaller, so that after equilibrium at the pier must remain an excess of thrust equal to 3/4 of that of the greater vault.

It is better to balance the thrust when the rise of the small vault is so reduced that the ratio of its height or rise (f to b) equals that of the great vault (F to B), and then the thru-

thrusts will be in the direct ratio of their spans (Fig. 351).

If the thrusts are to be entirely equilibrated, the rise of the smaller vault must be still less (see the dotted line in Fig. 352). By sufficiently flattening the small vault equilibrium of the thrusts is always made possible, but seldom is this solution possible in architectural respects. In any case so far as possible, the rise of the little vault is to be reduced instead of being increased, for one is to be particularly warned of very pointed lancet arches, that they are always statically disadvantageous (See p. 54 above) as especially conceivable in this case. If the narrow vault must be carried to the same height as the wide one, in place of a slender pointed arch it is best to employ a flatter stilted arch as shown by Fig. 352. Therefore is increased the thrust of the pointed a arch and it is applied higher, both having a favorable effect.

If the thrust cannot be equilibrated by a suitable rise, then must one pass to an artificial increase of the weight of the narrow arch, best attained by extra masonry on the cross arch (Fig. 353).

If the middle vault springs higher, its thrust exceeds more, then the excess masonry on the cross arch may even produce a stiffening by which the thrust is partly carried above the smaller cross arch (Fig. 354).

With a greater difference in height a solid wall over the c cross arch would be too heavy and would too much increase the thrust of the little cross arch. One must then place openings in the resisting wall to reduce its weight, but over it must be received the thrust of the principal vault,(Fig. 355). An inclined arch is most suitable for this. Thus entirely of itself it forms the buttress system, which soon after its adoption was further perfected in a wonderful manner.

Determination of width of buttress.

Just as in great constructions the ground forms of the buttress are placed beside each other, in the further treatment a and development of the walls, the buttress and flying buttress will find in the proper place their justification in connection with the entire development of church architecture; here is at first concerned to learn to know the required width or depth of the abutment and the stresses occurring in it. The correct dimensioning of the thicknesses of the walls and piers is a c

question for mediaeval architecture of such importance, that several successive Chapters are to be devoted to it.

So far in the lack of something better, men have directed t themselves according in rules of construction which were taken from the traditions of the latest middle ages,or established with much acuteness by modern masters. (On this see later the development of the plan of the church). For moderate proportions these are mostly good, but naturally they lose their value, as soon as particular cases arise, that may even lead to conceivable errors. Never allow to such rules a feeling of safety, a circumstance that has perhaps alienated many young men from mediaeval architecture. But one has confidence in his constructions, when he first clearly realizes the action of the forces and can directly work with them. (Note). The simple composition and resolution of forces, which have recently been carried to such high importance by Graphic Statics, affords an extremely convenient and easily understood means, that for present p purposes is so much more valuable, since it gains access to m matters almost unknown to mathematics, it assumes as preliminary knowledge nothing more than the theory of the parallelgram of forces, which proves that the diagonal of a parallelogram represents the cagnitude and dierection of a resultant, or that may be resolved into two components represented by the sides of the parallelogram, or conversely may replace two such components. (Note). In the course of our times, rather from ignorance or convenience employing a more costly substitute for a cheaper sonud construction, modern architects have not been a ashamed to erect seeming ribbed vaults with a complicated network of lattice girders and wire netting covered by mortar.

2. Magnitude and Location of the Thrust of the Vault against the Abutment.

If it be to obtain the forces or more correctly the stresses in an abutment, then must one first know the thrust exerted a against the abutment by the vault. Although this results from the previously described static properties of the vault, it w will be described here, so as it comes in question for the abutmenton account of the better connection.

Every vault exerts an oblique pressure against its abutment, more nearly horizontal the flatter is the vault. (Figs. 356, 357). This pressure W against the abutment may be resolved

into a horizontal component H and a vertical component V, the first being called the horizontal thrust and the second the abutment load. There may be taken at pleasure in the calculation either the oblique thrust W or its two components.

The abutment load V always equals the weight of that portion of the vault resting on this abutment.

The horizontal thrust varies not alone with the magnitude a and distribution of the weight, but very particularly with the ratio of the rise of the vault. In Figs. 356 and 357 V is assumed the same, but on the contrary H becomes very diffeeent on account of the unequal inclinations, that naturally have the greatest influence on the depth of the abutment.

To obtain the thrust against the abutment are given several methods, which so far as already mentioned for vaults, will again be repeated briefly here.

Obtaining the thrust against the abutment. 1. By the aid of the line of support.

1. By constructing the line of support, which is more fully explained under vaults (p. 52), one obtains the clearest and most reliable representation of the course of the compressile stresses in vaults, at the same time the end forces of the p pressure line directly give the oblique pressure against the abutment in magnitude and direction.

For the tunnel vault the line is obtained for a strip of perhaps 1 m wide, for the cross vault each line of pressure is separately obtained for the ribs and the cross arch and the common thrust is composed of that at the springing of the vault.

In every arch or vault is possible a great number of lines of support (Fig. 358). As most favorable is first to be designated as I, that deviates as little as possible from the middle line (more correctly stated, that has the least angle pressures --- on this see later). Besides this are steeper lines of support, the former giving a smaller and the latter a greater pressure against the abutment. If the mortar cannot resist tension, then neither of the lines of support broduced by the loads to be expected must leave the vault anywhere, but it is better to establish the condition that the line must remain within the kern (middle third). As permissible limits are to be regarded on the one hand the line of support II in Fig. 558,

the steepest lying within the middle third, on the other hand being III, the flattest.

If it is desired to make a truly certain investigation for the depth of the abutment, this is to be made separately for the two limiting positions II and III. The steeper one will require a rather weaker, and the flatter one a somewhat stronger abutment. For thin and high vaults both values usually coincide quite closely.

It is usually advisable to determine the depth of the abutment according to the flatter line III, for one is then certain not to make the abutment too weak in any case.

2. Approximate graphical procedure.

2. An approximate graphical method of obtaining the thrust of the vault is very simple, if one employs not the entire line of support but only its end forces. These end forces may be approximately obtained, for they must always be the components of a resultant of all external forces acting on the vault. The latter consist only of its own weight with any extra loads on the vault.

If one has a vault symmetrically shaped and loaded, only one half is considered (Fig. 359). The upper end force at the crown must be horizontal in this case and besides must pass through the kern of the cross section. There is drawn a horizontal to obtain the location and direction of the upper end force H, b but not its magnitude. The weight G of one half the vault is computed, that must act through its centre of gravity, and it cuts the horizontal in the point O. Through this point O must also pass the force W against the abutment, whose direction is obtained by assuming its intersection e with the abutment; as such is here taken the outer limit of the kern (at one third distance from the external angle of the bed). Besides the locations thus obtained, also to find the magnitudes of the forces H and W the weight G is laid off downward from o at a definite scale (for example 100 kil = 1 cm), and through its ends are drawn parallels to the components, by which the parallelogram O i c b is produced, the lengths of its sides O i and O b being the desired magnitudes of the forces H and W at the same scale. If an unsymmetrical vault exists, then the corresponding method is employed for the entire vault instead of for one half, (Fig. 360).(Also see the preceding p. 57 and Figs. 128, 129).

8. Approximate method of calculation.

3. The approximate mode of obtaining the thrust against the abutment is nearly allied to the preceding. First is calculated the magnitude and location of the weight G acting in one h half the vault (Fig. 361), then assuming the probable intersection of the end forces at d and e. For the lower point e is established the equation of moments. This is based on the fact, that a structural part (here on half the vault) can only be in equilibrium, when the moments (force × lever arm) of all existing forces about any point are neutralized. Here comes into consideration only the three forces G, H and W, the last of which disappears since it passes through the point e and its lever arm = O. Thus the moment equation is $G \times a = H \times h$, by which the upper horizontal thrust is computed as $H = \frac{G\,a}{h}$.

Since all forces must be statically equilibrated in vertical and horizontal directions, and as in every vertically loaded vault the horizontal thrust at top and bottom must be the same, at the same time is thus found the horigontal thrust acting on the abutment. The vertical load V on the abutment is also known, being just as great as G. Having the components H and V, then one also has their resultant W.

Location of the pressure at the crown and at the abutment.

It is recognized that obtaining the pressure against the abutment is a very easy matter, there being only a certain difficulty in choosing the most suitable points of intersection d and e. If their locations were accurately known, then would o one have not an approximate but an exact procedure. But an exact obtaining of the forces is now not possible everywhere for a vault, since many accidental things concur, and therefore t the given procedure can be regarded as entirely adequate for practice. If one is in doubt, how the points d and e are to be assumed, a clear conclusion may be obtained by the construction of one or more lines of support (first method). In most cases will it be advisable to assume the point d at the crown toward the intrados, and on the contrary the point e toward the extrado

If the springing of the vault is backed with masonry and bonded into the wall, then it is difficult to assume a definite bearing area on the abutment. In some cases this can be placed at the first oblique bed in which is assumed a point of intersection e′ (Fig. 361). But it will generally be simpler in such

cases to take the point e in the vertical face of the wall M M, then taking care for safety that this is taken rather too high than too low. The case may very easily occur, that the backing can be utilized in transmitting the thrust of the valut and a much flatter line of support be formed than the first view of the vault makes probable. The most probable point e usually l lies about 1/5, 1/4 or even 1/3 of the rise above the impost.

With an unsymmetrical or loaded vault (Fig. 360 or 360a), obtaining the forces by calculation is also again similar to that my drawing, the vault being regarded as a whole and the magnitude and location of its total weight G being first computed. Then are assumed the points e_1 and e_2 with the approximately tangential direction of the end forces W_1 and W_2, their magnitudes then being determined. By the graphical method this was done by constructing the parallelogram of forces, but here is first established the equation of moments about the point e_1 to find the force W_2; then the equation of moments about e_2 to obtain the force W_1 against the abutment. It is then to be considered that this is not the pressure against the abutment, but is the counter pressure obliquely upward of the abutment that is to be used in the calculation. (Reaction of the abutment. Fig. 360a).

General requirements for equilibrium.

Forces in the interior of the body or at the surface of contact of two bodies are known to exist in pairs, and thus the pressure that one body exerts on the other always causes an equal and opposed counter pressure in the other body. If one undertakes statical investigations in a body or a part of it, it is regarded as being taken from its surroundings and for them is added to each cut surface the counter forces acting there. Then all forces must be in equilibrium, but this is the case when the three following conditions of equilibrium are satisfied.

1. From any point as pivot must the sum of all moments with right hand rotation equal the sum of all moments with left hand rotation.

2. the sum of all forces acting vertically downward must equal the sum of all forces acting vertically upward.

3. The sum of all forces acting horizontally to the right must equal the sum of all forces acting horizontally to the left

To apply the two last conditions to forces with oblique direction, they must first be resolved into their vertical and horizontal components.

By the aid of these three requirements Statics is known to solve most problems, also for the present simple obtaining of the forces in the abutment in Fig. 361 are they applied, but it is to be added thereto, that the end forces H and W are not to be inserted with the direction shown in Fig. 361a, but as shown as counter pressures in Fig. 361b. Id the case be less simple, for example if the weight G represents a greater number of external forces, then their course as found is to be always regarded as the same.

In describing the three ways for obtaining the thrust against the abutment, it is not stated what species of vault is assumed but they apply directly to the tunnel vault, yet may be directly transferred to the cross vault.

Thrust of cross vault with straight ridge.

For a simple cross vault with straight ridge and without swelling as easily seen, Figs. 362, 362a, it gives about the same force acting on the abutment, as for a tunnel vault of the same cross section and with the same ground area. In both vaults act the same three forces G, H and W. The resulting load G is nearly the same in both in magnitude and location. (in the cross vault it is often somewhat smaller, on account of less backing masonrw, but its lever arm is somewhat greater --- in coated vaults the difference is more marked). In both vaults the horizontal thrust at top must lie at the same height d in the upper bed. The height e of the intersection of the resulting lower thrust of the vault likewise only exhibits slight variations. The only essential difference consists in this, that in the t tunnel vault the thrust is distributed along the entire width m p of the buttress in the plan of Fig. 362, while in the cross vault it is transferred to a single point at Ca

Thrust of a swelled cross vault.

If a strongly swelled cross vault exists with projecting ribs and cross arches, which at the same time also shows a raising of the crown, one is to proceed in the same manner, only that it is more difficult to fix the height of the upper horizontal thrust. Fig. 363 shows such a vault in cross section and plan. The thrust will be distributed over the entire length r n of

the cross section through the crown. A portion will be transmitted by the compartments and another portion by the cross section of the cross arch. Now on the longitudinal section is assumed an average height for the horizontal thrust as the horizontal line x x, where then the cross arch receives a relatively large portion, especially when the crown is strongly raised. Generally will the average location of the thrust at the crown be assumed rather low than high for greater security. When one has thus equilibrated the thrust at the crown and has assumed the lower intersection for the thrust, the vault is again considered as if it were a tunnel vault. It is conceived that instead of the cross vault is a corresponding tunnel surface with the average direction of the pressure and the same distribution of the weights, which is indeed usually termed the ideal tunnel vault. By its aid can very quickly attained the aim, though t this is exposed to the reproach of a certain superficiality, that one cannot avoid in general by mathematical accuracy in vaults, and that secondly one is able to pursue farther the investigation as desired by thoroughly following the transmission of the pressure.

Thrusts of raised cross vaults.

For a very strongly raised vault (Fig. 364a in section and Fig. 364 in plan), an ideal tunnel vault d e may likewise be assumed for it, and the thrust be found by the aid of the computed weight G. There the point e is to be placed higher than elsewhere, since it is to be assumed that a certain part C D s inplan of the compartment transfers its thrust above the side arch (see p. 50). For a greater raise such a use of the ideal tunnel vault in fact may become somewhat fanciful, and it is therefore better, at least to consider separately the portion of the compartment pressing above the side arch. For this is drawn the little ideal tunnel vault d_1e_1 with the weight G_1, and introducing for the remaining part of the half bay a second and greater ideal tunnel vault $d_2e_2$with the corresponding weight G_2. In this way is first separated the thrust that falls on the side arch or the solid wall, from that referred to the springing, which is often desirable for the further investigation of the abutment.

If in important cases one is not satisfied by this, it is p permissible to follow the previous indications with increased

accuracy as desired.

Explanations of the Tables of Weights and horizontal Thrusts of simple tunnel and cross vaults.

Although according to the preceding it is right easy to compute the thrust of the vault with the required accuracy, it still appears desirable for yet further simplification of the most common species of vaults to prepare a Table of the rise and thickness of vaults and building materials (Table I). The Table is obtained on the basis of constructed lines of support and by the use of the simple formula, H h = G a (Fig. 365), a and it is correct for symmetrical cross vaults of square or s slightly rectangular plan that are but slightly raised. it is applicable to vaults with any size of bay, since the weights V^o and H^o are given in units per q m of the plan. These numbers are multiplied by the area (in q m) of the part of the vaults loading the abutment considered, in order to give the vertical load and horizontal thrust on the abutment.

To estimate the weights and thrust by the ground area may at first appear rather venturesome, since in vaults of different dimensions may arise certain variations in the amount of backing masonry and in the arch members; but an investigation shows that these differences fall within very narrow limits in the average forms of vaults, and by giving the thrust as a calculation made by the assumption of a second value. For vaults of different form, which for example have masonry on the cross a arches or separate additional loads, the Tables are naturally not applicable.

The lengths given (lever arm of weight etc.) are expressed in ratiosto the span or rise. The span is taken as the clear distance between the walls, or when such are considered, are to be understood as between the side and cross arches, but on the contrary the height of rise is taken from the basal area (top of capital if no stilting exists) to the underside of the compartment at the crown. If the vault is raised, an average rise is to be taken.

The Table separates vaults according to their height into five groups:- I to V with a ratio of rise to span of 1:8, 1: 3, 1:2, 2:3, 5:6. Each group has the same subdivisions from a to f, containing the material and thickness of vaults, For vaults not exactly falling within the group or divisions may be inter-

interpolated values.

Vo == weight per q m of ground plan including the compartments, the projecting moulded arches, a moderate masonry backing and a plastering of the underside 1 to 1 1/2 cm thick. As dimensions of bricks is assumed the German normal standard of 25 × 12 × 6 1/2 cm, as the unit weight of bricks and mortar is assumed per cu. m 1600 kil for ordinary bricks, 1200 to 1300 kil for very light porous bricks (when arches and spandrels a are calculated for hard bricks, 2000 kil for sandstone and 2400 kil for rubble in lime mortar.

For vaults filled over with floor under f, for average weight of brick compartments, filling and floor is assumed 1600 kil per cu. m (the weight of vaults filled over varies according to their size and therefore only can be given for vaults of fixed dimensions (see examples in last line f).

a = lever arm of the resultant weight passing through the centre of gravity of the part of the vault resting on the abutment (for example one half the vault). This lever arm varies from 1/6 to nearly 1/4 of the span, according to the steepness of the vault, and is to be measured from the face of the wall or of the side arch.

b = lever arm of the horixontal thrust or the rise of the line of support or of the ideal tunnel of support. By this is to be understood the difference in height between the horizontal thrust at top and the lower transfer of the pressure of t the abutment. As the limit of the abutment is considered the face of the wall or the vertical plane tangent to the face of the side arch. This length h is at least to be carefully found, since in the same vault are possible flatter and steeper thrusts, and for safety the rise of the line of support is not taken too great, and as a rule this height becomes notably less than the rise of the vault; h varies in the Table between 3/4 and 9/10 of the rise of the vault.

x = height at which the abutment reaction cuts the face of the wall or of the side arch. This height is measured upward from the basal area if the vault, i.e., in vaults not stilted from the top of the capital or impost moulding. For the determination of the depth of the buttress is required this height, and concerning its accuracy, see what is said under h.

Ho = horizontal thrust per q m of basal area of the part of

the vault resting on the abutment, for example a half bay. With regard to the variations possible, two values are given here, the larger being rather for small and the smaller for great bays.

It is interesting to compare the thrust H_0 and the weight V_0 for half vaults of different heights.

According to this Table these average:-

Rise 1 : 8, H_0 is to V_0 as 2 : 1.
Rise 1 : 3, H_0 is to V_0 as 3 : 4.
Rise 1 : 2, H_0 is to V_0 as 3 : 7
Rise 2 : 3, H_0 is to V_0 as 1 : 3.
Rise 5 : 6, H_0 is to V_0 as 1 : 4.

For superficial estimates these ratios may be noted; for pointed cross vaults of average heights and about 2/3 rise is to be expected a thrust about equal to 1/3 the corresponding weight of the vault (one half), and which passes into the wall at about 1/4 the height of the rise.

In the last column of the Table are given as examples the weights and thrusts for two cross vaults, calculated for dimensions of 4 × 4 and 8 × 8 m, with the assumption that two adjacent bays meet at one buttress (see C in Fig. 366). the loading area m n p r then has the area of a half vault.

The thrust at an angle D of the wall (Fig. 366) is produced by a small part p r q D of the vault and accordingly is notably less. It is sufficiently safe to take in each of the two directions D k and D g the thrust half as great as that at C. Instead of the side thrust D k and D g may naturally be introduced the diagonal thrust D d in the direction of the arch. This is always less than the thrust at C (7 : 10).

For rectangular bays (Fig. 367) the thrusts at the point C and E differ. At both points indeed rests a half bay m n p r or r t q u, but the spans C F and E F are unequal, and consequently of vaults with equal rises, the short direction have a smaller ratio of pier and therefore a smaller thrust. At the angle D in vaults not swelled and for the rectangle, the direction of the thrust falls in the diagonal. The Table gives no accurate values for very much elongated bays, weights and thrusts are then a little too small in the longitudinal direction and abundantly great in the transverse direction. But if rectangular bays do not differ too much from the square, then the Table can always be applied to them, and for the ratio of

the rise must always be taken in the direction of the thrust considered.

Table I. Weights and horizontal thrusts of vaults. Fig. 365) Upper headings of the columns. From left to right.

Classification of vault.

V_o = weight of one q m ground area.

a = lever arm of resultant of weight.

h = lever arm of horizontal thrust.

Z = height of pressure on abutment above springing of vault.

H_o = horizontal thrust per q m of plan of loading portion of vault.

Example I. Vaults 4 × 4 m.

V = weight of one half. H = thrust of one half.

Example II. Vaults 8 × 8 m.

V = weight of one half. H = thrust of one half.

(left vertical column).

I. Ratio of rise 1 : 8.

a. Compartments 1/2 porous brick thick.

b. 1/2 hard brick or 3/4 porous brick thick.

c. 3/4 hard brick or 1 porous brick thick.

d. 1 hard brick or 20 cm sandstone thick.

e. Rubble 30 cm thick.

f. Brick vault filled over with floor 32 cm thick at crown.

II. Ratio of rise 1 : 3.

a. Compartment 1/2 porous brick thick.

b. 1/2 hard brick or 3/4 porous brick thick.

c. 3/4 hard brick or 1 porous brick thick.

d. 1 hard brick or 20 cm sandstone thick.

e. Rubble 30 cm thick.

f. Vault with filling and floor 32 cm thick at crown.

III. Ratio of rise 1 : 2.

a. compartment 1/2 porous brick thick.

b. 1/2 hard brick or 3/4 porous brick thick.

c. 3/4 hard brick or 1 porous brick thick.

d. 1 hard brick or 20 cm sandstone thick.

e. Rubble 30 cm thick.

f. Brick vault with filling and floor 32 cm thick at crown.

IV. Ratio of rese 2 : 3.

a. Compartment 1/2 porous brick thick.

b. 1/2 hard brick or 3/4 porous brick thick.

c. 3/4 hard brick or 1 porous brick thick.

d. 1 hard brick or 20 cm sandstone thick.

e. Rubble 30 cm thick.

f. Brick vault with filling and floor 32 cm thick at crown.

V. Ratio of rise 5/6 to 6/6.

a. Compartment 1/2 porous brick thick.

b. 1/2 hard brick or 3/4 porous brick thick.

c. 3/4 hard brick or 1 porous brick thick.

d. 1 hard brick or 20 cm sandstone thick.

e. Rubble 30 cm thick.

f. Brick vault with filling and floor 32 cm thick at crown.

Table I. Weights and horizontal thrusts of Vaults.

Kind.		V_o	a	h	Z	H_o	Ex. I V	Ex. I H	Ex. II V	Ex. II H
I.	a.	200	0.22 - 0.23 s	0.90 f	1/8 - 1/6 f	360 - 400	1600	3200	6400	11500 kil.
	b.	270	Aver. 2/3 s	or	,,	500-- 550	2160	4400	8600	16000
	c.	370	,,	1/10 s	,,	700-- 750	2960	6000	11800	22400
	d.	500	,,	,,	,,	950 -1000	4000	8000	16000	30400
	e.	850	,,	,,	,,	1600 -1700	6800	13600	27200	51000
	f.	---	0.20s = 1/5 s	,,	,,	---	5800	11000	26000	46000
II.	a.	230	0.19-0.21 s	0.85-0.75f	1/6-1/4f	160- 180	1840	1440	7400	5100
	b.	310	Aver. 1/5 s	Or	,,	220 - 240	2480	1920	9900	7000
	c.	420	,,	3/10 . 1/4 s	,,	300 - 350	3360	2640	13400	9600
	d.	570	,,	,,	,,	420 - 450	4560	3600	18200	13400
	e.	1000	,,	,,	,,	710 - 750	8000	6000	32000	22700
	f.	---	0.17 = 1/6 s	,,	,,	---	7300	5200	37500	23000
III.	a	260	0.17-0.20 s	0.80-0.70 s	1/5-1/3f	110 - 120	2080	960	8300	3500
	b.	350	= 1/6-1/4 s	Or	,,	140 - 160	2800	1280	11200	4500
	c.	480	,,	2/5 - 1/2 s	,,	190 - 220	3840	1760	15400	6100
	d.	700	,,	,,	,,	280 - 320	5600	2560	22400	9000
	e.	1200	,,	,,	,,	480 - 550	9600	4400	38500	15300
	f.	---	0.16 s	,,	,,	---	8000	3800	41600	17600
IV.	a.	290	0.17-0.20 s	0.80-0.72f	1/5-1/4 f	90 - 100	2320	800	9300	2900
	b.	380	= 1/5-1/8 s	Or 1/2 s	,,	110 - 130	3040	1040	12200	3500
	c.	530	,,	,,	,,	160 - 180	4240	1440	17000	5100
	d.	750	,,	,,	,,	220 - 250	6000	2000	24000	7000
	e.	1300	,,	,,	,,	400 - 430	10400	3440	41500	12800

Kind.	V_o	a	h	Z	H_o	Ex. I. V	Ex. I. H	Ex. II. V	Ex. II. H
V. a.	340	0.16–0.19 s	0.80–0.75 f	1/5– 1/4 f	80 – 90	2720	720	10900	2600
b.	450	,,	or	,,	100 –110	3600	880	14400	3200
c.	650	,,	Aver. 2/5 f	,,	150– 160	5200	1280	20800	4800
d.	900	,,	,,	,,	210– 230	7200	1840	28800	6700
e.	1500	,,	,,	,,	350– 370	12000	2960	48000	11200
f.	---	0.15 s	,,	,,	---	13000	3000	77800	17500

3. Obtaining the Line of Support and Stresses in the Buttresses.

Security against sliding, overturning and crushing.

When by calculation, construction or by Table I the thrust of a vault has been found, or which is the same, both its components H and V (Fig. 368), it is then to investigate the resistance of the supporting body. That must be ensured against sliding, overturning and crushing.

Sliding of the abutment.

A sliding or slipping of the abutment is seldom to be feared with the usual materials of construction. It may occur if with soft mortar the angle between the direction of the pressure a and bed is less than 45° to 60°, or with hardened mortar if t this angle is under 30° to 45°. Slipping can be prevented by a changed position of the bed, or less effectively by dowels. Care is to be taken not to make the damp-proof bed of soft pitchy material, since this has already permitted the sliding of an entire mass of masonry. Such isolating beds must only be arranged where the compression acts almost perpendicular to the bed, and further care is to be taken by choice of material and accessories, that the isolating material remains neither too soft nor too smooth.

Overturning:

Safety against overturning is easily proved. The equation of moments is established about the outer dangerous angle (A in Fig. 340). It must then result that the sum of the moments of rotation in a favorable direction (force × lever arm) is greater than the sum of those with unfavorable rotation (overturning). For a simple case was already described the investigation for overturning on p. 124 (Fig. 340). --- For that drawin in Fig. 368, the mass of masonry pushed from both sides cannot overturn about the angle A; so long as $G_1 \times a_1 + G_2 \times a_2 + W_2 \times n$ is greater than $W_1 \times m$.

If it is desired to examine whether overturning cannot occur about the other angle E, the moments can be found for that case.

Instead of the forces W_1 and W_2 acting on the abutment, there may naturally be taken their horizontal and vertical components as in Fig. 340.

Overturning can most easily occur at the bottom of the foundation (surface I in Fig. 369 and pivot A), then at the surface

of the masonry resting on the wider footing (II, pivot B), and finally at each abrupt recession of the cross section (III, p pivot C). The stability at these places must be examined. If the overturning moment exceeds at any point, then the overturn of the masonry above it can only be prevented by special means, and to this belongs the clamping of the wall at the back. Likewise the strong adhesion of a mortar able to resist tension m may hinder overturning, and in fact many dangerous walls are thus held. But the resistance of the masonry to tension cannot be safely counted on even with cement mortar, since perhaps already invisible hair cracks produced by the mode of execution, chushing, temperature stresses, etc., exist, and the connection may fail. A firm adhesion of the wall to the footing generally does not exist, if the overturning moment is too great, at most the earth beside it may be useful, but this is a scarcely reliable factor.

Resistance and allowable compression.

Safety against overturning does not alone suffice; compression must nowhere exceed the allowable limit for the material. By investigation of the materials coming into consideration c concerning their resistance have been obtained the following values.

Material.	Kil. per cm q. Crushing.	Shearing.
Granite, diorite	500 - 1800	60 - 100
Limestone, dolomite	300 -1000	a. 30 - 50
		b. 50 - 70
Sandstone	180 - 900	a. 13 - 40
		b. 15 - 40
Limestone tufa, light	80 - 200	30
Clinker bricks	250 - 700	40 - 60
Good wall bricks	100 - 200	15 - 30
Porous or hollow bricks	40 - 100	---
Cement mortar	100 - 200	18 - 30
Lime mortar, hard	50 - 90	---

Note. A = resistance in direction of bed; b = same perpendicular to bed.

With regard to defects in materials (cracks and crevices) a and imperfect bedding of the compressed surfaces, the allowable stress must remain far below the ultimate resistance to compression. Particularly, stones with small resistance to shear

should not be too strongly loaded, since by bad transmission of the compression may easily occur crushing. For the same reason the resistance to shear or thrust is placed in the Table. Since the resistance to shear is less in the direction of the grain, it is bad to set some kinds of stone on bed, still one need not be too anxious concerning selected blocks without defects, as proved by numerous examples from the middle ages.

The resistance of mortar and stone for masonry must be cared for at the same time. For limestone or sandstone set with cement or lead, according to the stone it is usual to allow 16 to 30 kil per q cm, for rubble in lime mortar 5 to 7 kil or up to 10 kil after hardening, for brickwork in lime mortar 7 kil, f for bricks in cement 11 kil, and for very good materials 14 kil. Since piers and walls of churches are carefully built, when the load of the vaults is only added after hardening of the mortar, good bricks in lime mortar may be stressed to 10 kil without hesitation and to 20 kil in cement, it being assumed t that official decrees do not place lower limits. Old works often show far higher pressures, 20 to 30 kil on bricks and 30 to 50 kil on cut stone are not uncommon.

Moderately good ground like loam or sand is loaded with 2 1/2 or 3 kil per q cm, and likewise here in old works (for example the tower at Ulm) are shown far higher pressures of 10 kil and more on yielding soil it is of greatest importance to equalize the areas of the foundations, so that the soil beneath all parts of the building may receive the same pressure if possible, since otherwise settlement is unavoidable.

Location of line of support.

When the resultant compression falls at the middle of the a area of cross section, it is uniformly distributed over that. The stress per unit area is then found directly by dividing t the pressure by the area. For example at the middle of a pier with 1/2 q m or 5000 q cm area rests a load of 11,500 kil, its own weight being 6000 kil, there is at the bottom of the pier a compression $= \frac{11,500 + 6,000}{5000} = 3\ 1/2$ kil per q cm.

But in the abutments of vaults the pressure seldom falls exactly at the middle of the cross section to be examined, and therefore approaches more or less to one side. The nearer the centre of pressure is to one side, the more is the pressure increased there, while it is reduced in like proportion at

the opposite side.

Location of the resultant compression in a cross section.

That the distribution od the stresses may be obtained, it is necessary for the intersection of the section concerned by the line of support be found, which is easily done by calculation or by the graphical method.

Obtained by drawing.

1. Graphical procedure (Fig. 370). To find the location and magnitude of the pressure on the surface A E, the weight G of the mass of the abutment above it with the thrust H of the vault are combined at their intersection O by the parallelogram of forces. Thereby are obtained the magnitude and direction of the desired resultant pressure R and its intersection F with the surface A E. Only the vertical component D comes into consideration as the actual compression on the bed, while the horizontal component S is opposed by the friction of the courses on each other.

2.Location by calculation.

2. Method by calculation.(Fig. 371). Not the thrust of the vault but its components H and V are introduced, and the equation of moments is established as follows for the point F sought, which is at the unknown distance x from E:-

1. $V x + G(x - m) = H k.$

From this is obtained the distance x and thus is fixed the position of the centre of compression F. The magnitude of the pressure R is composed of those of its components D and S, but these are easily obtained. D must equal the sum of all vertical loads, thus is here:.

2. $D = G + V.$

S must equal the algebraic sum of the horizontal forces, here being only H:-

3. $S = H.$

If more forces occur than in this example, they are to be c combined in the same way by the graphic or analytic method. I The course is always the same, whether a wall, buttress or middle pier is to be examined, whether a single vault or any larger number of vaults act at different heights and at different sides.

Example. A prismatic buttress 10 m high, 1 m wide and 2 m deep in the direction of the thrust is built of rubble weighing 2400

kil per cu. m., and receives at the height of 8 m the pressure of a vault, whose thrust H = 3000 kil and its weight V is computed at I-00 kil. The centre of gravity is 1 m from the inner side. The equation of moments for the point P sought is:-

$$9600\ x + G(x - 1.00) = 3000 \times 8.00.$$

Weight of pier G = 10.00 × 2.00 × 1.00 × 2400 = 48,000 kil.

$$9600\ x + 4800\ x - 48,000 = 3,000 \times 8.00$$

$$57,600\ x = 72,000. \quad x = 1.25\ m.$$

The centre of pressure is thus 1.25 m from the inner edge, 0.75 from the outer one, and 0.25 m from the centre of gravity.

The magnitude of the vertical compression is :-

$$D = G + V = 48,000 + 9600 = 57,600\ kil.$$

Horizontally:- $S = H = 3000$ kil.

The horizontal portion S is relatively very small, and it w will be opposed by the resistance of friction with entire safety. The vertical part D is the pressure under consideration. If it passed through the middle, the compression everywhere would be $= \frac{57,600}{20,000} = 2.88$ kil per q. cm. But in the present t transfer of pressure it would be greater at the external edge, as will be shown somewhat later.

Course of line of pressure.

In the manner described can be determined the location of the compression in any cross section. For vertical piers or a walls it suffices to examine the bottom area on the foundation or the under surface of the footing. If the supporting body recedes or has offsets upwards (height III in Fig. 369), it will then be necessary to test the location of the compression under each of these. It it is desired to represent the middle line of pressure in its entire course from top to bottom, the mass is dividet in horizontal layers as in Fig. 372, and for each area are combined all pressures acting above it into a resultant compression. If the intersections of the compression are connected by a curve, this represents the line of pressure.

With a greater depth of the abutment is advisable a vertical subdivision instead of the horizontal (Fig. 373) and the pressure of the vault is combined with the weights of the steps.

In simple cases can one already conclude from the location of the line of pressure whether the depths of the abutment are sufficient or not so. If the latter seems too weak, it can be made deeper and the line of pressure be found anew. For impor-

important cases must one take into account the magnitude and distribution of the stresses.

Distribution of the stresses; Kern of cross section.

If we return again to a single cross section for which the location and magnitude of the resultant compression are determined in the method described, two cases are to be distinguished, for the pressuere may lie either within the kern of the cross section or outside it, and what this means will be explained immediately.

If the pressure passes through the middle or more correctly through the centre of gravity of the cross section, it is uniformly distributed over the entire area, which is indicated in Fig. 375 by the little arrows of equal length directed upward (which do not represent the pressures downward, but the equal reactions exerted by the support). Each q cm receives the pressure $p = \frac{D}{F}$, where D = the total pressure in kil and F = area of cross section in q cm.

If the pressure D is moved somewhat from the centre of gravity to a point nearer A (Fig. 376), the pressure increases at A, while it diminishes at B. It retains at the centre of gravity the average pressure $p = \frac{D}{F}$.

Kern of the cross section.

If D moves still farther, the case must finally occur, where the pressure at B = 0 (Fig. 377). This position of the pressure is important, since in most cases it is not willingly passed, for if D is moved farther, the pressure is no longer distributed over the entire area. For a square or rectangle (plan, Fig. 378), this limit lies at 1/3 of the entire length A B. If the pressure conversely approaches the edge B, the pressure at A would become = 0 when D reaches a. For a transfer sidewise would result the limiting points f and g in the same manner. If the points a p f g are joined a quadrilateral is formed, which is termed the kern of the cross section. The length and breadth of the kern is 1/3 the length and breadth of the rectangle. Only when the resultant pressure falls in the kern is each part of the area under compression, and if this is required, then the pressure must move only within the middle third. If it is diagonal, its possible location is still smaller, for it is to be considered that diagonally the width of the kern is only 1/6 the length of the diagonal.

The kern of a circle is also a circle with a diameter 1/4 of that of the larger circle.

The kern of a triangle is a similar triangle with a length of 1/4 and an area of 1/16. The angles of the triangular kern lie on the centers of the lines joining the middles of the sides (Fig. 380).

When the pressure is at the limit of the kern, then for the rectangle and circle the maximum pressure at the edge is twice the average pressure p; for the triangle it is on the contrary only 1 1/2 times the average pressure.

Two other plans may come into consideration by the combination of wall and buttress, and are represented in Figs. 381 and 382, with the insertion of the principal measures for the dimensions of the kerns.

If it is desired to find the limiting points of the kern for any other plan, for example the point P in Fig. 382, then is employed the formula:- 4. $w = \frac{J}{F z}$.

Here w = distance of the point sought from the centre of gravity; J = moment of inertia about the gravity axis Y Y; F = area of the entire surface; z = distance of the neutral fibre (without pressure) from the centre of gravity. With this formula c can be found the limiting points of the kern figure for any cross section.

Pressure within the kern.

If the pressure D lies neither on the border of the kern nor at the centre of gravity, but is at any other point of the kern --- see Fig. 376 --- the neutral fibre must be conceived to lie at a point O outside the area. If the location of this point can be determined, then can be found the entire distribution of the pressure, for it is only necessary to lay off the average pressure p above the centre of gravity s at any definite scale (for example 1 kil = 1 mm or 1 kil = 5 mm), and to draw through the end of p a line to O. The height of this line from the base A B denotes at each point the magnitude of the pressure per q cm.

The location of the neutral fibre O is known if its distance z from the centre of gravity is known, and can be found by equation 4, solved for z:- 4a. $z = \frac{J}{F w}$.

Here again J = moment of inertia; F = area, and w = distancce of the force D from the centre of gravity. The moments of inert

about the axis Y Y are for the plans considered as follows.

Rectangle (Fig. 378) $J = \frac{b\ h^3}{12}$.

Square (upright or diagonal) $J = \frac{h^4}{12}$.

Circle (Fig. 379) $J = \frac{\pi\ D^4}{64} = 0.049\ D^4$

Triangle (Fig. 380) $J = \frac{b\ h^3}{36}$.

Octagon (regular) $J = 0.055\ d^4$.

Plan in Fig. 381 $J = 1.083\ a^4$ (about axis X X, $J = 2\ 1/3$

Plan in Fig. 383 $J = 3.619\ a^4$ (about axis X X, $J = 2\frac{5}{12}$ a

Example. For the example described on p. 140 --- pressure on the area of the cross section of a buttress --- there was obtained p = 2.88 kil as the average pressure per q cm. The transfer of this pressure toward the edge was not yet sought, but is now to be found by the given formula 1a. The point of intersection P (Fig. 370) was given at a distance x = 1.25 m from the inner side B, which is 25 cm from the centre of gravity or middle; and thus w = 25, and further the area F = 200 × 100 = 20,000 q cm, $J = \frac{b\ h^3}{12} = \frac{100 \times 200}{12} = 66,666,667$, so that $z = \frac{66,666,667}{25 \times 20,000} = 133$ cm. This distance z is laid off to the right from the middle, and from the end point O is drawn in the given way the oblique line O K, and now can be measured the pressure at every point.

If it is desired to omit the drawing, the pressure at any point can be found directly by the use of the next formula for the calculation.

5. $$p_1 = \frac{D}{F} \pm \frac{D\ w\ c}{J}.$$

Here again D = the resultant pressure, w = its distance from the centre of gravity, F = area of the surface, J = corresponding moment of inertia, and finally c = distance of the point examined for its pressure from the gravity axis. The sign + is to be used for the side most strongly compressed, the sign - for the side less strongly compressed.

Example. The preceding example will again be used, where the rectangular area has b = 100 cm breadth and h = 200 cm length, with a total pressure of D = 57,699 kil. That falls at a distance w = 25 cm from the centre of gravity. The moment of I has alrea-

already been computed as J = 66,666,667.

If the maximum pressure p_1 is to be found for the outer side, then for the distance c = 100 cm from the centre of gravity:-

$$p_1 = \frac{57,600}{20,000} + \frac{57,600 \times 25 \times 100}{66,666,667} = 2.88 + 2.16 = 5.04 \text{ kil.}$$

Hence the maximum pressure at the outside = about 5 kil per q cm, which is regarded as permissible for the intended construction of the buttresses in brickwork with lime mortar.

The pressure at the inner edge is found just the same by using the negative sign and p_2 = 0.72 kil. (Also p_2 = 2 × 2.88 - 5.04 = 0.72). It is unnecessary to compute other values of p, since these are known to increase uniformly from the inner to the outer edge.

Pressure outside the kern.

When the resultant pressure falls outside the kern, the line of 0 pressure lies within the cross section (0 in Fig. 38). There result compressile stresses on the side with the force, but on the opposite side are tensile stresses. At the centre of gravity is the average pressure = p = $\frac{D}{F}$ as before, for the symmetrical plans (rectangle and circle). The maximum pressure = 2 p greater than the maximum tensile stress at the other side. To obtain the neutral fibre and the distribution of the stresses there remains in force formulas 4 (or more correctly 4a and

Masonry with tensile stresses.

If the masonry is in condition to resist tensile stresses, then will in any excentric position of the pressure, the distribution of the stresses be obtained in the same way. The pressure may even lie outside the masonry (Fig. 384), whereby the compression and the tension at the edges are both increased, until with an infinite distance of the force D they pass into infinitely great values.

Masonry without tensile stresses.

Now for the reasons given earlier the masonry can resist no tensile stresses. The parts not compressed have no part whatever in the transmission of the force, they rest on each other without stress, and under the circumstances even a more or less open joint may be formed here. The transfer of the pressure o occurs just as if this part of the cross section did not exist. For example on a rectangular plan, Figs. 385, 386, on which the resultant pressure D acts at the point P outside the kern, the stress is distributed as if a surface with the length A B exist

with zero pressure at the point $\bar{r}$. If this zero pressure is at L, then the centre of pressure P must represent the limit of the kern, and it follows that for rectangular or square cross sections, the length A P is to be laid off thrice from the location of the point L.

The average pressure d acting at the middle of the compressed area (b n) must equal the pressure divided by area' thus $d = \frac{D}{bn} = \frac{D}{3\,b\,m}$.

The maximum pressure at the edge is twice as great:-

thus 6; $d_1 = \frac{2\,D}{3\,b\,m}$. 7; $N = 3\,m$.

These formulas apply to square and rectangular sections of masonry with the breadth b, where the compression D acts outside the kern and at a distance m from the outer edge. By equation 6 is found the maximum corresponding d_1 per q cm, and by formula 7 results the length n to which continues the compression on the area.

For a triangular area n = 2 m if the compression approaches the vertex. For other compound sections the relations for the position of the compression outside the kern are less simple, so that their demonstration here must be omitted.

It is to be emphasized, that in masonry which can resist no tension, the resultant force (or the line of pressure) can never be close to the outer edge, since there the pressure would soon approach an infinite value, thus pulverizing the material would result. Passing beyond the edge would be followed by ruin. Only for masonry able to resist tension can the line of pressure pass outside the surface so long as the material resists.

For compression in the next Table are collected the edge pressuresfor different locations of the line of pressure, indeed for rectangular plans of masonry with or without resistance to tension. The values are referred to the average pressure p, t that each q cm would receive by an uniformly distributed compres

Thus $p = \frac{\text{compression}}{\text{area}} = \frac{D}{F}$ or $\frac{D}{b\,l}$.

Table of magnitudes of edge pressures on a rectangular area of masonry with different positions of the resultant compression

m = distance of resultant from outer edge.

d_1= edge pressure at front. Masonry without tension.

d_2= edge pressure at rear. ,, ,, ,,

n = distance of zero line from front edge. ,,

p_1 = pressure at front edge. Masonry with tensile resistance.
s_1 = tension at rear edge. " " " "
n = distance of zero line from front edge. " "

m =	d_1	d_2	n	p_1	s_1	n
	Resultant acts within the kern.					
1/2 l	p	p	Infinite	Same values as at left.		
5/12 l	1 1/2 p	1/2 p	1 1/2 l	"	"	"
1/3 l	2 p	0	l	"	"	"
	Resultant acts between kern and edge.					
1/4 l	2 2/3 p	---	3/4 l	2 1/2 p	Tens. 1/2 p	5/6 l
1/6 l	4 p	---	1/2 l	3 p	" p	3/4 l
1/12 l	8 p	---	1/4 l	3 1/2 p	" 1 1/2 p	7/10 l
0	Infinite	---	0	4 p	" 2 p	2/3 l
	Resultant acts outside section.					
- 1/2 l	---	---	---	7 p	" 5 p	7/12 l
- l	---	---	---	10 p	" 8 p	5/9 l

p = compression per q cm with uniform distribution.

Application to abutments of old buildings.

When it concerns the repair or rebuilding of old structures n: trustworthy, it is particularly indicated to compute weights and thrusts as far as possible and to determine the compression. There the abutments require far more attention than the vaults. For a vault not that is supported by centering is seldom dangerous after hardening, even when large cracks appear, so long as the abutments remain immovable.

Cracks appearing later in such vaults indeed are produced by the yielding and settlement of the abutments.

If the vault has received many coats of whitewash or color, these can usually give an acceptable indication, whether the yielding of the abutments occurred on a particular occasion or continually. In the last case a further progress of the movement is to be feared. In repairing the vault, only the principal arches, the springings and the backing of the spandrels merely require closer attention, cracks in the compartments, particularly in the swelled parts, are less dangerous.

If the claims of the abutments are conceivable, where with otherwise good condition of the masonry much larger values can be allowed than in new structures, there come in consideration anchors, clamps, increased foundations or the addition of sur-

supporting masses (buttresses). If several vaults combine, equalization of the thrusts may be useful (p. 127), yet alterations in loads and thrusts in old works always demand special oversight.

Neutralizing the thrust by tie anchors is generally cheapest, but on account of flexibility and perishableness of iron it is only reliable from necessity. The strength of the anchor is c computed according to the magnitude of the thrust of the vault, which may be approximately found by the statements of the preceding Chapter, ind in proper cases also by Table I (p. 135). to each q cm area of cross section of the iron may be assigned a tension of 700 to 1000 kil.

When the stress obtained shows that stability is only due to the tensile resistance of the mortar, then must repairs or rebuilding be undertaken with particular care. If thorough relief cannot be created by removal of the injurious thrust, then a carefully inserted iron clamp at the dangerous place would be proper, that can receive tensile stresses on the loosening of the mortar. The strength of the clamp is obtained according to the preceding from the magnitude of the tensile stresses existing. Also here can be safely assigned to iron 700 to 1000 kil per q cm, or about half as much to bronze.

Insufficient foundations.

In most cases the yielding of the abutments is to be referred to the condition of the soil, and therefore attention must be especially devoted to the bottom of the foundation. Tensile stresses between earth and masonry are entirely excluded. If the compression falls near the outer edge (Fig. 388), there arise at this very considerable pressures. But it is yet more conceivable than in a mortar bed, where after the hardening of the mortar no further crushing occurs. A yielding ground only comes to rest late or even not at all, and the more strongly pressed edge b: alternate yielding of the ground as well as by each change of loading or vibrations of the masonry (for example by wind) will be pressed deeper, which will result in a continual sinking of the masonry at one side, until its fall can be no longer postponed. By suitable distribution of the footings in new structures can this danger be prevented almost always without additional masonry, as shown by comparing Figs. 388 and 389, that require no further explanation after

the preceding statements relating to the distribution of the pressure. In old works may be required a subsequent extension of the foundations in the given direction, but this must always be regarded as a very difficult work, to be undertaken with t the same care as the addition of large masses of masonry to be described.

If sinking walls are to be supported by buttresses placed before them, this addition is to be made with special care, if it is to fulfil its purpose properly. Both in the middle ages (especially in the 15 th century) as well as in modern times were built numerous subsequent supports, partly with very good and partly with quite doubtful results. By the observation of such conditions is it recognized, that usually one of the three events shown in Figs. 390, 391 and 392 has resulted.

In Fig. 390 the pier has sunk into the ground by settlement of the mortar and by pressure, being entirely separated above from the wall. The pier is useless and the wall stands in consequence of its own resistance, perhaps it would be even better without the addition.

Fig. 391. The pier has se settled like the preceding with the wall pressing against it at the same time. Each of the two masses has carried out a rotation, while at the line of contact the bonding stones are sheared off. After the hardening of the new masonry and the comppresion of the ground under the front edge, the movement may entirely or nearly cease, and the wall finds a certain bearing on the supporting body.

Fig. 392. The bond betwëen the pier and the wall is sufficient, so that neither loosening or shearing is possible, so that these act as a common body. The two preceding results are presented, yet the buttress in settling forms a part of the wall as an overhanging weight, until at last a condition of rest occurs, and then this construction has an effect far more allowable than the two first mentioned.

A certain movement of the wall to be described last is generally opposed with difficulty. If the wall were actually in m motion, then with the addition of the stress this would continue a little farther, till a condition of rest appears. In this is also no difficulty, but it is important that the subsequent movement does not exceed a reasonable amount. For this purpose care is to be taken, that the ground beneath the foun-

foundation is not loosened unnecessarily, that the footing of the latter is as hard as possible, and that masonry shrinking least or not at all be employed. Most consideration is usually required by the soil, that has been compressed under the older parts, but must first experience this compression under the new ones. In the circumstances it is feasible to previously compress the ground somewhat by loading and perhaps also by careful tamping. That the dangerous wall is to be shored before removal of the earth scarcely requires mention.

For particular cases may be advisable constructions like Fig. 392a. (A similar arrangement was made for the securing of a part of the cloister of the cathedral at Riga). The earth before the old masonry may remain undisturbed, the new foundation be carefully constructed independently and carried somewhat deeper, the earth under it can previously or after the completion of the foundation, be compressed by loading. The supporting mass exerts an allowable counter pressure, it can be built against it in its lower parts without bonding in the beds a d, and after settlement the upper part is to be ensured against shearing, best by bonding with a cut block of tough granite or limestone.

4. Thickness of Walls and Buttresses.

Obtained by trial.

The preceding chapter gives the means for ensuring to a buttress a given form and depth the degree of this safety or for obtaining its resistance. If it be to first sketch for a definite vault, the depth of the abutment will depend on statical investigations, then may an abutment be assumed and the resistance found for it. According as it is weak or unnecessarily strong will be made other assumptions, until a suitable depth is found.

Direct calculation of the depth.

Instead of this assumption in the circumstances may the aim be reached directly by calculation as shown in the next example.

Example. The forces H and V of a vault acting at a height k above the ground are known. (Fig. 393). The vault is to be supported by prismatic piers t m in height, whose depths are twice their widths. These sides x and x/2 are calculated on the assumption that the line of pressure passes exactly through the limit of the kern, so that A P = x/3.

The equation of moments for the intersection P is established which is in this case;. $\frac{2}{3} V x + \frac{G x}{6} = H k$.
This weight G is the volume of the pier × its unit of weight g per cu. m., thus:- $G = \frac{x^2}{t g}$.
Inserting this weight in the previous equation, there results:- $\frac{2}{3} V x + \frac{1 t g x^3}{12} = H k$, or $x^3 + \frac{8 V}{t g} x = \frac{3 H k}{t g}$.

Thus is obtained an equation of the third degree, that can be solved by Cardan's formula or more simply by repeated assumptions of a value for x.

Quite similar is the procedure for other forms of abutments.

If the compression does not pass exactly through the limit of the kern, then can be obtained another determination of its location, for example the intersection P is assumed to fall at x/12 distant from the middle or perhaps 0.30 m from the outer edge. The equation of moments for P again gives an equation of the second or third degree, that is to be solved for the desired depth of plan.

In this manner were computed the depths of the abutments in the following Tables II, III and IV.

Explanations of Tables II, III and IV for calculating the depths of abutments. (Also see Table I, p. 135).

The Tables contain the depths to abutments in metres. For continuous walls as well as for vertical buttresses and those diminished upwards, with definite forms of plan and heights. They do not make unnecessary the otherwise sufficiently simple obtaining of the depths of abutments for special cases by the aid of the line of support etc. (See the preceding p. 140 et seq.), but they afford a preliminary value only for the designer, and will serve yet more to give a clear view of the great variation of depths according to rise, kind of vault, span and height of the resistance to the vault.

The values are obtained gy computation on the basis of the weights and thrusts of Table I. They give only the depths required by the vaults. Particular conditions must still be considered, and thus the perhaps existing wind pressure against h high roofs may make advisable a relatively small addition to the depth of the abutment.

Kind of vaults In the first column are given the different vaults according to rise and thickness of the compartments, the existence of the projecting ribs and backing of the usual

are assumed. (Otherwise is applicable what has been already s stated in regard to Table I). The calculation is made for a square bay 4 × 4 m = 16 q m, and one 8 × 8 m = 64 q m areas; for other sizes are to be interpolated the values.

Rectangular vaults. If the rectangle does not differ too much from the square, the depth of its abutments equals that of a square bay of the same area in plan and the same rise. For the rectangle is the ratio of the rise $(\frac{rise}{span})$ to be measured in the direction of the thrust under consideration, and it is less (flatter) in the long direction than in the short one, so that the Table gives for the longer direction of the rectangle a relatively deeper abutment than for the shorter one.

Row of vaults, separate vaults, corners. The depths of abutments are computed for a row of vaults, so that at each abutment two adjacent vaults meet (see C and C_1 in Fig. 366). With a single vault enclosed by abutments (for example a tunnel vault) the depth may be somewhat less, and likewise at ends of rows of vaults (D in Fig. 366). This reduction in abutment walls may then amount to 1/4 the depth, if the walls are high a and the vaults are light, if the vaults are heavy and the abutments are low, then the tabular values are taken for separate vaults. The same saving up to 1/4 of the depth occurs for buttresses, if only their depths are reduced, but if widths and depths are both reduced, then this reduction may amount only to 1 or 2 tenths of the width and depth. If at the angle a diagonal buttress is employed instead of two buttresses, then it is to be made as the Table gives for a continuous wall.

Height of abutment. The height of the abutment wall or buttress is assumed equal to the height of the top of the keystone, since in churches the masonry usually ends at this height. If the buttresses are lower, then the difference will be abundantly compensated by the weight of the connecting wall. --- The depths are calculated for a lower height of abutment (from footing of foundation to top of keystone is 5/4 of span, for an a average one (2 1/2 span), and one is desired one with an infinite height. By an infinite height of abutment the depth does not become infinite, but it approaches a not excessively great limit. This is to be taken for the interpretation of values for lofty vaults (of towers etc.). That the height of the abutment has another limit by the crushing of its materials by its own

weight is self evident.

Location of pressure at the edge. The numbers given in the Table under this title are lower limits, to which one must not approximate, since the abutment of this depth (without resistance to tension) would certaily fall.

Location of the pressure within the kern. The values given under this designation afford sufficient depth of abutment, in case the edge compression is not too great (see somewhat farther below). With too great edge pressure is proper a small increase of the depth of the buttress, but on the contrary if the edge pressure is very small, then may the depth be reduced somewhat in any case, yet must still be kept sufficiently far from the limit of falling.

Location of the compression at the middle comes into consideration only in Table IV for buttresses diminished upwards. If the proper depth be employed for this location of the compression, a uniform distribution of the pressure over the cross section is obtained in the most favorable way.

Magnitude of maximum compression. If the pressure passes through the limit of the kern, the pressure on the inner side = 0, and at the outside edge exists the maximum pressure, for whose approximate statement are given the little numbers, that mean:-

1. Maximum pressure per q cm, 0 to 4 kil.
2. ,, ,, ,, ,, 4 to 7 kil.
3. ,, ,, ,, ,, 7 to 11 kil.
4. ,, ,, ,, ,, 11 to 14 kil.
5. ,, ,, ,, ,, 14 to 21 kil.
6. ,, ,, ,, ,, 21 to 28 kil.

With the location of the pressure at the middle (Table IV) the given pressure extends over the entire cross section. If the compression is too great for the intended material, the abutment must be made somewhat deeper.

If the openings for windows do not extend from buttress to buttress but a solid piece of wall remains at each side, then must the widths of piers in Tables III and IV be reduced by 10 to 20 per cent.

(Additional explanations of the Tables.

A′ = cut stone. Resultant at edge of section.

A″ = cut stone. Resultant ad edge of kern.

B′ = brick. Resultant at edge of section.

B″ = brick. Resultant at edge of kern.

a. 1/2 porous brick vault.

b. 1/2 hard or 3/4 porous brick.

c. 3/4 hard or 1 porous brick.

d. 1 brick or 20 cm sandstone.

e. 30 cm rubble vault.

f. Brick vault with filling and floor above.

	A′	A″	E′	E″	A′	A″	E′	E″	A′	A″	E′	E″
V. Rise 5/6 (u = 2.80 m.												
a.	0.26	1 0.44	0.31	1 0.51	0.40	2 0.70	0.50	1 0.83	0.55	0.95	0.68	1.20
d.	0.36	1 0.57	0.40	1 0.63	0.62	2 1.05	0.71	1 1.20	0.88	1.55	1.10	1.85
f.	0.36	1 0.59	0.41	1 0.64	0.71	2 1.80	0.84	1 1.50	1.10	1.95	1.40	2.40

E. Vault 8 × 8 m = 64 q. m.

	t = 10 m.				t = 20 m.				t = infinity.			
III. Rise 1/2 (u = 3.30 m).												
a.	0.63	2 1.05	0.73	1 1.25	0.75	3 1.30	0.90	2 1.55	0.85	1.50	1.05	1.80
d.	0.91	2 1.50	1.10	1 1.80	1.15	3 1.95	1.85	2 2.30	1.35	2.35	1.70	2.90
f.	1.20	2 2.00	1.40	2 2.30	1.55	3 2.65	1.85	2 3.10	1.90	3.30	2.35	4.05
IV. Rise 2/3 (u = 4.50 m).												
a.	0.45	2 0.80	0.58	1 0.95	0.65	3 1.10	0.78	2 1.30	0.80	1.35	0.95	1.65
b.	0.48	2 0.90	0.60	1 1.00	0.70	3 1.20	0.83	2 1.40	0.85	1.50	1.05	1.80
c.	0.60	2 1.00	0.70	1 1.20	0.83	3 1.40	1.00	2 1.75	1.05	1.80	1.25	2.20
d.	0.68	2 1.15	0.78	1 1.30	0.95	3 1.60	1.15	3 2.50	1.20	2.10	1.50	2.55
e.	0.85	2 1.40	0.98	2 1.60	1.25	3 2.10	1.45	3 1.90	1.65	2.85	2.00	3.45
f.	0.95	2 1.55	1.05	2 1.70	1.40	3 2.40	1.65	3 2.80	1.90	3.30	2.35	4.05
V. Rise 5/6 (u = 5.70 m).												
a.	0.38	2 0.64	0.45	2 0.75	0.57	3 0.98	0.68	2 1.15	0.73	1.30	0.90	1.55
d.	0.53	2 0.86	0.60	2 0.98	0.86	3 1.45	1.05	3 1.70	1.20	2.05	1.45	2.50
f.	0.70	3 1.10	0.72	2 1.20	1.25	4 2.10	1.45	3 2.45	1.90	3.35	2.35	4.10

Note. Resultant at edge causes overthrow! Resultant at edge of kern ensures abutment if not too great. This is given by the separate single figures. (See explanation of Tables on p. 153).

Table II. Thickness of straight abutment wall.

Length half occupied by openings. Height of wall taken to keystone of vault.

Thickness of wall given in metres.

	Small height of wall.				Aver. height of wall.				Infinite height of wall.			
	A′	A″	B′	B″	A′	A″	B′	B″	A′	A″	B′	B″
	A. Vault 4 × 4 m = 16 q m.											
I. Rise 1/8 (u = 0.60 m).												
I.	t = 5 m. height of wall.				t = 10 m. Height of wall.				t = infinity.			
a.	1.00	1 1.75	1.25	1 2.10	1.10	2 1.90	1.35	1. 2.30	1.15	2.00	1.45	2.45
d.	1.55	1 2.65	1.85	1 3.15	1.70	2 2.90	2.05	1. 3.50	1.85	3.15	2.25	3.90
f.	1.80	1 3.10	2.15	1 3.60	1.95	2 3.35	2.35	1 4.05	2.15	3.70	2.65	4.55
II. Rise 1/3 (u = 1.25 cm)												
a.	0.60	1 1.02	0.70	1 1.20	0.70	2 1.20	0.83	1 1.40	0.78	1.35	0.95	1.65
d.	0.89	1 1.50	1.05	1 1.75	1.05	2 1.80	1.25	1 2.15	1.25	2.15	1.50	2.60
f.	1.00	1 1.70	1.15	1 1.95	1.25	2 2.10	1.50	1 2.50	1.50	2.55	1.80	3.15
III. Rise 1/2 (u = 1.60 m.												
a.	0.44	1 0.74	0.53	1 0.88	0.53	2 0.92	0.65	1 1.10	0.63	1.10	0.78	1.35
d.	0.65	1 1.05	0.75	1 1.25	0.86	2 1.45	1.00	1 1.70	1.05	1.80	1.30	2.20
f.	0.76	1 1.25	0.87	1 1.45	1.00	2 1.70	1.20	1 2.00	1.25	2.20	1.55	2.65
IV. Rise 2/3 (u = 2.20 m).												
a.	0.35	1 0.59	0.40	1 0.67	0.46	2 0.79	0.55	1 0.91	0.58	1.00	0.71	1.25
b.	0.38	1 0.64	0.44	1 0.72	0.51	2 0.89	0.62	1 1.05	0.66	1.15	0.81	1.40
c.	0.43	1 0.71	0.49	1 0.81	0.60	2 1.05	0.71	1 1.20	0.78	1.35	0.95	1.65
d.	0.48	1 0.79	0.54	1 0.88	0.70	2 1.20	0.83	1 1.40	0.92	1.60	1.10	1.95
e.	0.55	1 0.91	0.62	1 1.00	0.88	2 1.45	1.00	1 1.70	1.20	2.05	1.45	2.55
f.	0.57	1 0.92	0.63	1 101	0.87	2 1.55	1.05	1 1.75	1.20	2.10	1.50	2.60

Table III. Depth of uniform Buttresses.

The Table contains depth X in m. Width is half the depth.

Pier rises in outline without offsets to height of keysone of vault.

	A′		A″	B′		B″	A′		A″	B′		B″	A′	A″	B′	B″
	Small height.						Average height.						Infinite height.			
A. Vaults 4 × 4 m = 16 q m area.																
Rise 1/2 (u * 1.60 m. t = 5 m.							t = 10 m.						t = infinity.			
a.	0.81	1	1.20	0.89	1	1.30	1.00	2	1.45	1.15	1	1.65	1.20	1.70	1.35	1.25
d.	1.00	1	1.50	1.15	1	1.60	1.35	2	1.95	1.50	1	2.20	1.65	2.35	1.85	2.70
f.	1.10	1	1.65	1.20	1	1.75	1.50	2	2.20	1.70	1	2.45	1.85	2.70	2.15	3.05
Rise 2/3 (u = 2.20 m).																
a.	0.64	1	0.94	0.69	1	1.00	0.89	2	1.30	1.00	1	1.45	1.10	1.60	1.25	1.80
b.	0.67	1	0.98	0.72	1	1.05	0.96	2	1.40	1.10	1	1.55	1.20	1.75	1.40	2.00
c.	0.71	1	1.05	0.75	1	1.10	1.05	2	1.50	1.20	1	1.70	1.35	1.95	1.55	2.20
d.	0.74	2	1.10	0.78	1	1.15	1.15	2	1.65	1.30	1	1.85	1.50	2.15	1.70	2.45
e.	0.79	2	1.15	0.82	2	1.20	1.30	2	1.90	1.45	2	2.10	1.80	2.60	2.05	2.95
f.	0.80	2	1.20	0.83	2	1.25	1.30	2	1.95	1.45	2	2.10	1.80	2.60	2.05	3.00
Rise 5/6 (u = 2.80 m.																
a.	0.47	2	0.70	0.50	1	0.73	0.80	2	1.15	0.90	1	1.30	1.05	1.55	1.20	1.75
d.	0.51	3	0.75	0.53	2	0.78	1.00	2	1.45	1.10	2	1.60	1.45	2.10	1.65	2.40
f.	0.49	4	0.72	0.50	3	0.75	1.10	2	1.60	1.20	2	1.75	1.70	2.50	1.95	2.85
B. Vaults 8 × 8 m = 64 q m.																
Rise 1/2 (u = 3.30 m. t = 10 m.							t = 20 m.						t = infinity.			
a.	1.30	2	1.90	1.45	1	2.10	1.55	3	2.25	1.75	2	2.25	1.80	2.60	2.05	3.00
d.	1.60	2	2.35	1.75	2	2.55	2.05	3	3.00	2.30	3	3.35	2.50	3.55	2.85	4.10
f.	1.90	2	2.75	2.05	2	3.00	2.50	3	3.65	2.80	3	4.10	3.10	4.45	3.55	5.10

Rise 2/8 (u = 4.5 m). t = 5 m. t = 10 m. t = infinity.

a.	1.00	2	1.50	1.10	2	1.65	1.40	3.	2.00	1.55	3	2.25	1.70	2.45	1.95	2.80
b.	1.05	2	1.55	1.15	2	1.65	1.45	3	2.10	1.65	3	2.25	1.80	2.60	2.05	3.00
c.	1.15	2	1.70	1.25	2	1.80	1.65	3	2.40	1.85	3	2.65	2.05	2.95	2.35	3.40
d.	1.20	3	1.75	1.30	2	1.90	1.80	4	2.60	2.00	3	2.85	2.30	3.30	2.60	3.75
e.	1.35	3	2.00	1.40	2	2.10	2.10	4	3.05	2.35	3	3.40	2.80	4.00	3.20	4.60
f.	1.40	3	2.05	1.45	3	2.15	2.25	4	3.30	2.50	3	3.65	3.10	4.45	3.55	5.10

Rise 5/6 (u = 5.70 m).

a.	0.78	3	1.15	0.83	2	1.20	1.10	4	1.60	1.20	3	1.75	1.65	2.35	1.90	2.70
d.	0.87	4	1.30	0.90	3	1.35	1.60	4	2.35	1.80	3	2.65	2.25	3.25	2.55	3.70
f.	0.91	6	1.35	0.94	5	1.40	2.00	4	2.90	2.20	3	3.20	3.10	4.45	3.55	5.10

Note. Resultant at edge causes overthrow. Resultant at border of kern ensures buttress if edge pressure is not too great. This is given by the prefixed figures.

Table IV. Depth of trapezoidal diminished Buttress.

The Table contains depth at bottom in m. Depth at top = 5/11 of depth at bottom.

Height of buttress is taken to the keystone of the vault.

A. Vault 4 × 4 m = 16 q m area.

	Small height of Vault. t = 5 m.				Average height. t = 10 m.				Infinite height. t = infinite.			
	A′	A″	B′	B″	A′	A″	B′	B″	A′	A″	B′	B″
Rise 1/2 (u = 1.60 m).												
a.	0.90	1 1.20	0.98	1 1.35	1.15	2 1.50	1.30	1 1.70	1.35	1.75	1.55	2.00
d.	1.10	1.1.50	1.20	1.1.65	1.50	2 2.00	1.70	1.2.20	1.90	2.40	2.15	2.75
f.	1.20	2 1.65	1.30	1 1.80	1.70	2 2.25	1.90	1 2.50	2.15	2.75	2.45	3.15
Rise 2/3 (u = 2.20 m.												
a.	0.70	1 0.95	0.75	1 1.03	1.00	2 1.35	1.10	1 1.50	1.30	1.65	1.45	1.90
b.	0.73	1 1.00	0.78	1 1.08	1.10	2 1.45	1.20	1 1.60	1.40	1.80	1.60	2.05
c.	0.75	2 1.05	0.79	1 1.15	1.20	2 1.55	1.30	1 1.75	1.55	2.00	1.75	2.30
d.	0.78	2 1.10	0.83	1 1.20	1.30	2.1170	1.40	1 1.90	1.75	2.20	2.00	2.55
e.	0.83	2 1.20	0.85	2 1.25	1.45	2 1.95	1.60	1 2.15	2.05	2.65	2.35	3.05
f.	0.83	2 1.20	0.85	2 1.25	1.45	2 1.95	1.60	1 2.15	2.10	2.70	2.40	3.05
Rise 5/6 (u = 2.80 m.												
a.	0.50	2 0.70	0.52	1 0.75	0.90	2 1.20	1.00	1 1.35	1.25	1.60	1.40	1.80
d.	0.53	3 0.76	0.55	3 0.80	1.10	2 1.50	1.20	2 1.65	1.70	2.15	1.95	2.50
f.	0.50	5 0.73	0.50	4 0.75	1.20	2 1.60	1.25	2 1.75	2.00	2.55	2.25	2.90

E. Vault 8 × 8 m = 64 q m area.

.	. A′	. A″	. B′	. B″	. A′	. A″	. B′	. B″	. A′	. A″	. B′	. B″
Rise 1/2 (u = 3.30 m.												
a.	Height of buttress t = 10 m.				Height t = 20 m.				Height t = infinite			
a.	1.40	2 1.90	1.60	1 2.10	1.75	3 2.35	2.00	2 2.65	2.05	2.65	2.35	3.05
d.	1.75	2 2.35	1.90	2 2.60	2.30	3 3.05	2.60	2 3.45	2.85	3.65	3.25	4.20
f.	2.05	2 2.80	2.20	2 3.05	2.80	3 3.75	3.15	2 4.20	3.55	4.10	4.05	5.25
Rise 2/3 (u = 4.50 m.												
a.	1.10	2 1.55	1.20	2 1.65	1.60	3 2.10	1.75	2 2.35	1.95	2.50	2.25	2.85
b.	1.10	2 1.55	1.20	2 1.70	1.65	3 2.20	1.85	2 2.45	2.10	2.70	2.40	3.05
c.	1.20	3 1.70	1.30	2 1.85	1.80	3 2.40	2.05	2 2.70	2.35	3.05	2.70	3.45
d.	1.25	3 1.80	1.35	2 1.90	1.95	3 2.65	2.20	2 2.95	2.60	3.35	3.00	3.85
e.	1.40	3 2.00	1.45	3 2.15	2.35	3 3.15	2.60	3 3.50	3.20	4.10	3.65	4.70
f.	1.45	4 2.10	1.50	3 2.20	2.50	3 3.40	2.75	3 3.70	3.55	4.60	4.60	5.25
Rise 5/6 (u = 5.70 m.												
a.	0.83	3 1.15	0.88	3 1.25	1.40	3 1.90	1.55	2 2.10	1.90	2.40	2.15	2.75
d.	0.90	4 1.30	0.93	3 1.40	1.80	3 2.40	1.95	3 2.65	2.55	3.30	2.95	3.80
f.	0.93	6 1.35	0.95	6 1.40	2.20	4 3.00	2.35	4 3.00	3.55	4.60	4.10	5.25

Note. Resultant at edge causes overthrow! Resultant at border of kern ensures safety of buttress, it pressure at edge is not too great. This is given by the left extra figures. (On importance of this Note see Note on Table III and explanation on p. 158). Resultant at middle produces on entire cross section the pressures given by left extra figures.

5. Thickness of Middle Pier.

The statical requirements for abutments treated in the two preceding Chapters apply in their full extent to middle piers of all kinds. Since the danger of sliding is scarcely to be feared here, three conditions relate to them.

1. The pier is safe from falling in any direction.
2. Nowhere is the permissible limit of compression exceeded.
3. The middle line of pressure must remain within the kern of thecross section, if possible.

The first condition is satisfied always as soon as the second is fulfilled. The third condition may also be neglected if the edge pressure remains small. Especially with good execution in cut stone, the crushing of the beds at one side and the opening at the other is so little to be feared, that a slight movement of the pressure outside the kern is generally permissible. Not to occupy the free space, men in middle piers go to the limit of stress judged allowable, yet in such cases they should not neglect to spread the foundation quite safely. To very slender piers will be given an increase with regard to the danger of buckling or crushing (more exact statements concerning safety from buckling cannot be given for lack of basis for masonry.

The most common cases of loading of the middle pier are already represented in Figs. 350 to 355. If it is desired to follow distinctly the course of the pressure from top to bottom of the entire pier, the graphical method is best employed, if it be only necessary to find the distribution of the compression on the ground area or on any other cross section, then the aim is reached just as well by calculation. (See p. 140 and t the example below). The graphical procedure frequently gives such acute intersections of lines in slender piers, that even for greater accuracy calculation is to be preferred in such cases.

Middle pier of a hall church.

Since the stress in the middle pier of a hall church is tolerably simple, it is especially suited for explaining the procedure for obtaining the compression. A definite case is therefore assumed.

Location of the copression in the pier.

Example 1. (Figs. 394, 395). A hall church with middle aisle 9 m wide and side aisles 6 m wide, with bays 6 m long, is divided by square piers set diagonally, 12 m high and 1.25 m squ-

square, thus being 1.77 m in diagonal length. Dividing arches 0.70 m wide and backed in spandrels to 2 m above the capital. Pier and dividing arch consist of sandstone weighing 2300 kil per cu. m. Vaults with sandstone ribs and cross arches are 1/2 brick thick and are built of ordinary bricks. (Weight 1600 kil. per cu. m). The cross section of both aisles shows a rise averaging 2/3 of the span.

Now the location of the centre of compression and the maximum stress in the area of the pier at the height of the floor is to be sought.

The forces in the vaults may be assumed by Table I (p. 135) and indeed (according to line IVb) the weight per q m area of plan is 380 kil and the thrust for each q m of plan is 120 kil. On the pier acts from each side half a vault of 27 or of 18 q m area, and accordingly the forces result:-

For the vault of the middle aisle $V_1 = 27 \times 380 = 10,260$ kil.

$H_1 = 27 \times 120 = 3,240$

For the vault of the side aisle $V_2 = 18 \times 380 = 6,840$

$H_2 = 18 \times 120 = 2,160$.

The height of the point of application of the forces above the capital may be taken at 1/4 rise, thus in the middle aisle being 1.50 m, in the side aisle 1.00 m.

The dividing arch with its backing may have a volume of 5 cu. m, and thus a weight of $5 \times 2300 = 11,500$ kil $= G_1$

The weight of the pier is computed at $G_2 = 1.25^2 \times 12.00 \times 2300 = 43,125$ kil.

The equation of monuments is then established for the sought point x for the middle axis, $G_1 (x + G_2)(x + V_1)(x + 0.35) + H(12.00 + 1.00) = V_2 (0.35 - C) + H_2 (12.00 + 1.50)$.

$$x = \frac{V_2 \times 0.35 + H_1 \times 13.50 - V_1 \times 0.35 - H_2 \times 13.00}{G_1 + G_2 + V_1 + V_2}$$

Inserting the values assumed above for V_2, H_1, etc., x = 0.20 m. i. e., the centre of compression lies 0.20 m = 20 cm sidewise from the middle. The kern measures only 1/3 of the side or 1/6 of the diagonal, and thus it has in the direction of the latter only a breadth of 29.3 cm or its half is only 14.7 cm. Thus t the centre of pressure P lies 5.3 cm outside the kern (see plan in Fig. 395a).

This little distance from the kern causes that on the inner

side of the pier a part remains without compression, may very well be termed permissible, in case the compression on the extreme edge is not too great. With a central pressure the compression on the unit area.= total weight divided by area, the former being $G_1 + G_2 + V_1 + V_2$ = 71,700 kil and the area = 1.25^2 = 1.56 q m = 15,600 q cm. Hence $\frac{71,700}{15,600}$ = 4.6 kil per q cm if pressure acts at the middle. If it falls on the edge of the kern, the maximum compression on the outer angle is twice as great and = 9.2 kil. It will now be somewhat greater, yet as may be estimated, there can be only 12 kil per q cm, which for good sandstone masoryy is not too high compression, and therefore the pier can pass as sufficiently safe.

The foundation will properly be extended outward, so that t the middle of its footing is moved about 20 cm from the middle of the pier, for the pressure to become central (see Fig. 395). If the footing weighs about 13,000 kil, there is a pressure t transmitted to its bottom = 71,700 + 13,000 = say 85,000 kil. If the soil can be loaded with 2.5 kil per q cm, there will be required an area of $\frac{85,000}{2.50}$ = 34,000 q cm = 3.4 q m, which is properly arranged as in Fig. 395a, shown in plan and in Fig. 395 in elevation. For an entirely reliable soil it is better to spread it still more and give it the form of the dotted rectangle (Fig. 395a).

In the example just given the line of pressure fell outside the kern of the area. If an entirely similar pier were employed instead of this set diagonally, with its sides parallel to the axes of the vaults, the pressure would lie within the kern and accordingly the edge pressure would be less. From this point of view, it is advisable to compare the current plans of piers.

Central plans of piers.

Most piers can be reduced to the four forms of plan, I and IV in Fig. 396, indeed the square(or rectangle),regular octagon, circle, and square set diagonally. It is assumed that the four plans have equal areas, and then their diameters in the direction of the thrust will be as 1.0, 1.10, 1.13, 1.41. The converse proportion is found in the dimensions of the kerns in the same direction, being as 1.00, 0.88, 0.85, 0.71. But it follows from this that for a location of the resultant pressure in the kern or near it, plan I is best and IV is most unfavorable, but conversely for the location of the compression near the outer

edge, I is most unfavorable and IV is most advantageous.

One is thereby convinced that it is best in all plans to examine two similarly located points of pressure P and P_1. If the first point P falls just on the border of the kern, it lies within I and II, but is outside in IV. The edge pressure will be greatest in IV, but a part m n o is at the inner corner and will remain without pressure.

The point P_1 lies at the outer edge in I, so that here destruction certainly follows, but in the other plans it still lies inside, although even in these the edge pressure is so great, that it is doubtful whether it will resist. Even in IV wi,, t the compression be distributed only over the area s t u, which scarcely contains 1/6 of the total area, and the maximum compression at s will be nearly 18 times as great as if the pressure were equally distributed.

However it is possible, that with an unfavorable location of the compression on pier IV, it may still maintain its resistance, when I has already failed and it is especially possible , when there occur unforeseen variations of the loads, that may occur by transfer of the wind etc. Certainly such important transfers of the compression toward the edge, even when they occur but occasionally, are already injurious to the durability of the pier on account of the loosening of the beds to be feared.

Extended and unusual plans of piers.

A plan combining the advantages of I and IV is that of a rectangle with the same direction as that of the thrust (Fig. 397), already employed in Romanesque churches. Similar advantages has also a Gothic round pier, that has projections or rounds in the direction of the thrust, but not in those of the dividing arches (Fig. 398); thus the pier from Mantes that is represented later in Fig. 426. The pier in the Market church of Hanover likewise has below rounds only in the direction of the aisle, while the rounds for the dividing arch are corbelled out above. But too great extension lengthwise disturbs the connection of the side aisles, and therefore men preferred yet more a central plan, so that the circular pier with four little shafts in Fig. 399 accordingly lies by its static effect between the circle and the diagonal square. Men frequently sought to reduce even the height of the pier, when the rounds of the middle aisle

did not extend down to the floor. This is also justified by the predominance of the thrust of the middle aisle, since already the inner side received little or no compression in this case.

It is generally an advantage to move the centre of the bottom section as far as possible toward the side aisle, but to place the upper load and particularly the centre of gravity of the dividiyg arch more toward the middle aisle, so as to oppose the predominating thrust of the middle aisle. Thus for example a pier unsymmetrical on the two sides as in Fig. 400, where t the architectural treatment permits, may be statically very suitable. It would have only one round at the slightly compressed side, but would have two rounds on the strongly pressed side and there form a broad base, besides being in this case moving the dividing arch of unsymmetrical form toward the middle aisle. By such treatment would one be able to even attain to lead the compression through the centre of gravity of the plan.

A wall on the dividing arch may be advantageously employed in balancing the forces, if its principal mass can be moved toward the middle aisle. If it serves to carry the roof framework with it, the effect of wind comes in question, for which see a special Chapter.

Equalization of thrusts of the vaults.

Most advantageously treated are always the statical conditions of a pier, when the variations in the loading are obviated and the thrusts of the vaults can be equalized on all sides. What method is to be followed in aisles of different widths is already indicated in Figs. 350 to 355. To more fully represent the great influence of a suitable equalization of the thrusts on the dimensions of the pier, let an example be inserted in addition to that previously treated.

Example II. In the hall church assumed in example I (Fig. 394) the middle pier of sandstone with an allowable cropression of 20 kil per q cm with a circular plan is to be made as small as possible, that the space may be least restricted. To equalize the thrusts of the vaults the cross arches of the side aisles are to be backed with masonry, and it is to be determined how heavy their backing is to be made and what cross section is to be given to the pier.

First is to be found the weight V_3 which is to be placed on one half the cross arch. It is assumed that the backing masonry will be so distributed that besides the sought vertical loading V_3 of the abutment, this shall exert a thrust $H_3 = \frac{V_3}{3}$ on the pier, at the height of 1.20 m above the capital and thus 13.2 m above the bottom of the pier. The pier will be about the smallest when the resultant compression passes through the middle of the bottom area, and if such is tha case, then the equation of moments is to be established for this middle point.

$V_1 \times 0.35 + (H_2 \times 13.00) + (H_3 \times 13.2) = V_2 \times 0.35 + (V_2 \times 0.35) + (V_3 \times 0.35) + (H_1 \times 13.50)$.

According to the previous example are to be inserted:--

$V_1 = 10{,}260$; $V_2 = 6{,}840$; $H_1 = 3{,}240$; $H_2 = 2{,}160$, and $H_3 = \frac{V_3}{3}$.

$10{,}260 + (2160 \times 13.00) + 13.20\frac{V_3}{3} = (6840 \times 0.35) + (3240 \times 13.5) +($

By this the unknown quantity V_3 is found = 3,559 kil.

If the masonry backing be made of sandstone with unit weight of 2300 kil, then to obtain this load are required $\frac{3559}{2300} = 1.55$ cu.
The entire cross arch will require twice this load or 3.16 cu. m of rubble backing. The area of the pier will now be sought. With the location of the pressure at the middle, 20 kil comes on each q cm so that the total weight divided by the area must = 20 kil.

The total weight consists of the loading and its own weight; the loading is $G_1 + V_1 + V_2 + V_3 = 11{,}500 + 10{,}260 + 6{,}840 + 3{,}559 = 32{,}159$, and the unknown weight of the pier $= \frac{D^2}{4} \times 3.1416 \times 12.00 \times 2300$.

Likewise the unknown sectional area $= \frac{D^2}{4} \times 3.1416$ or $\frac{D^2}{4} \times 3.1416 \times 10{,}000$ q cm.

Thus $(38{,}185 + \frac{D^2}{4} \times 3.1416 \times 10{,}000 = 20$.

Or $\frac{D^2}{4} \times 3.1416 \times 10{,}000 \times 20 - \frac{D^2}{4} \times 3.1416 \times 12.00 \times 2300 = 32{,}1$

$D^2 = 0.238$, and $D = 0.49$, i.e., the pier requires only 0.49 m in bottom diameter. In the upper part of the pier the compression is not exactly central, so that here in spite of the small loading there would be necessary a slight increase in size, w which can be taken into account by seeking the point of intersection at the height of the capital. But there also occur other considerations.

For piers of this slenderness (diameter scarcely 1/24 of the height) there must already be taken into account the danger by bending or buckling, and besides in view of accidental variations of the loading, and finally on account of the architectural

appearance, a greater diameter is held to be advisable, so that the diameter is to be incriesed to at least 70 cm.

Thus there occurs with central compression a pressure of 11 kil on each q cm. The foundation is to be lconsiderably extended from the pier, since it has to transfer about 50,000 kil including its own weight. If the soil can be loaded with safety to 2.5 kil per q cm, a ground area of $\frac{50,000}{2.50} = 20,000$ q cm or 2 q m are required, which would yet be somewhat increased on a not entirely suitable soil. Just where one builds boldly on the ground should he not neglect a good foundation, since by such neglect occur most injuries.

Interesting is a comparison of the size of the pier now obtained with that assumed in the first example.for the same church. While the stress is equal in both, the square pier with 1.25 m side requires 18.7 cu. m of masonry, while the round pier 0.70 m diameter contains only 4.7 cu. m, so that there is a saving of about 14 cu. m of cut stone for each pier. There is certainly an addition to this of 3 cu. m of rubble for loading the cross arch, and further the external buttress must be somewhat deeper, since the backing of the cross arch increases the thrust. But this is trivial in comparison to the saving in size just where this is so strongly required.

One recognizes by this example how justifiable was the endeavor in the middle ages to arrange all forces as advantageously as possible, and he will further see how valuable for the execution is even a merely approximate (though sufficiently uncertain))determination of the statical conditions of the construction

Basilica without the buttress system.

The course of the investigation to be established is the same, that has just been shown for the pier of the hall church, except that here besides the pier to be considered is also the p part of the clearstory wall carried on it. We shall first take no account of the roof and the wind pressure, taking the forces acting aside from these, when these particular stresses will be taken up later and the procedure be repeated.(See the following Chapter on roof load and wind load).

The forces are best combined graphically from above to below, in order first to obtain a clear view of the entire course of the stresses, and then is taken up the most dangerous cross s

section for closer examination, when for accuracy calculation can be employed, (See examples on p. 155, 157), as well as the explanations on p. 140.

As a rule there comes in question the cross section at the height of the springing of the vaultof the aisle (I in Fig. 401), then the bottom of the pier (II) and finally the bottom of the foundation (III).

By a skilful estimate of the masses in the clearstory wall, the pier of the vaults, for which the graphical method offers indications in a speaking way, one is able to lead the line of pressure within wide limits as may be advisable in each case. By backing with masonry under the side roofs, there may be obtained particularly favorable results. All the numerous refined and instructive experiments that the middle ages made in t this direction, can we appreciate graphically and thereby our less trained constructive feeling may be strengthened, and even elevated to the same height as that of the old masters.

When the middle aisle is not carried so high, then may be m made possible solutions very satisfactory statically without the certainly more perfect but always more costly system of t the flying buttresses.

Basilica with flying buttresses.

Forces at ends of the flying buttresses.

Like all other masonry arches the flying buttress exerts a thrust at each end, whose magnitude depends on the corresponding height of the point of support, as well as the weight, span and form of the arch. (See Figs. 402 to 405). If we wish to f find the line of support of the arch to test the suitability, the arch is then divided by vertical lines into slices (Fig. 402) and on the load line are laid off their weights in the usual way (see preceding p. 52). The line of pressure furnishes then the end forces, that are especially concerned. Otherwise there are also found approximately the thrust forces by t the frequently described and simplified methods by calculation or graphics (p. 130). The latter in which the direction of the end forces are assumed by estimation and their magnitudes are determined from the weight of the arlh is inserted in Figs. 403 to 405 for illustration.

Figs. 403 to 405 show how greatly varied are the effects of the flying buttress according to the form chosen. The lower

pressure E_2 is important for the depth of the buttress, and t the upper pressure B_1 has the problem to entirely or partly neutralize the thrust of the vault.

In the arch in Fig. 403 (S. Ouen at Rouen) the pressure E_1 is directed obliquely downward, so that besides the horizontal thrust H_1 a portion of the weight V_1 of the arch is thrown on the bearing.

The most commonly occurring arch of Fig. 404 is almost or quite horizontal above and accordingly exerts a horizontal pressure E_1.

The flat curved and steeply inclined arch of Fig. 405 (Halberstadt) exerts a considerable end force E_1 obliquely upward, i.e., it does not load the upper bearing, but even tends to lift it upward. In consequence this arch is suited to receive a part of the weight of the clearstory wall and to conduct it to the external buttress, thus relieving the middle pier.

For all this and yet other varied forms of arches the middle ages offer manifold examples, and which of them is to be chosen depends in each case on the effect desired. Usually at the upper end will be produced neither a loading nor a lifting effect, but only a horizontal thrust opposed to the thrust of the vault. In this case a quadrant is suitable (arch in Fig. 404).

In early Gothic the quadrant was already preferably replaced by half a pointed arch, thereby obtaining a statically arch c curve. Generally the centre of the pointed arch was placed but little beyond the middle line (point a in Fig. 404), so that the arch is nearly horizontal at top and also exerts a quite or nearly horizontal force. But if it be desired to receive a part of the load and to reduce the depth of the supporting buttress, they were employed very steep arches (for example at H Halberstadt, Regensburg and Notre Dame at Semur). Therefore if it be to design a flying buttress that exerts an entirely definite counter pressure, then must one start with the upper end, sketch approximately the desired line of pressure and then distribute the weight of the arch, so that the desired line of p pressure results from the graphical construction. There is assumed at first that the usually existing line of pressure with a quiet loading has the same or a somewhat flatter curve than the middle line of the arch.

Stiffness of the flying buttress.

An important requirement for every flying buttress is a sufficient degree of stiffness, i.e., the arch must not only be able to offer the ordinary counter pressure corresponding to its form, but in variations of loading it must also be able to transfer other and especially greater forcer without destruction. Such variations can first be produced by very considerable wind pressures on very high middle aisles.

In Fig. 402 are drawn two lines of pressure,,the more strongly curved one offering rather small counter forces (O N in the added force diagram of Fig. 402a), but the pressures of the f flatter line for the same weight have those much more important. (O′M″O′N′ in Fig. 402a). The flatter is the line of pressure, the greater become the end forces and naturally also the compression forces which the arch can receive. It results from this that in the arch, according to whether a small or great force is transferred to it, there is found a more curved or a straighter transfer of the pressure. The arch form must be so created, that it can safely contain all possible lines of pressure for the loadings that may occur.

The chief requirements for a good flying buttress may be summarized in this, that it is not too heavy, for generally only a moderate thrust is exerted, but in particular cases an important counter thrust may be offered.

If from this point of view the construction of the ancients is examined, one cannot be sufficiently surprised by the refined art with which they correctly understood all requirements, if certain types of arches are taken.

Figs. 402 and 404 show the most common forms, consisting of an arch with complete coping, the latter suited to receive flat lines of pressure. The coping must therefore by well jointed; men soon came to place special value on reliable construction of their roofing, that was particularly utilized for transmitting compression. The intermediate masonry could then be made lighter and even resolved into tracery.

Fig. 406 (Amiens) shows a resolution of this arfh into a lower curved and an upper straight cross arch. The lower curved part transfers the usually acting thrust, but on the contrary the upper straight cross arch has the task to receive any variable forces. Since each one of its cut blocks is supported

from beneath, the coping is always in equilibrium, whether a great or a small longitudinal force acts in it. It can be compared to a shore, whose stress may change from 0 to the border of buckling. If the stress be too great, then would occur buckling, which is prevented downward and it made difficult sidewise but is possible upward, yet where the weight of the out b blocks oppose it.

Some also sought to prevent the upper coping from buckling upward by curving it somewhat downward, and brought it into direct connection with the lower arch as a counter arch by means of tracery (Fig. 407). The manifold shapes of flying buttresses are thus not alone designed for architectural effect or for a better water channel, but they first serve important structural purposes.

With high middle aisles men passed to two flying buttresses over each other, Partly as Viollet-le-Duc opines, to create a great base for the wind pressure distributed over a greater surface, and chiefly probable to give the clearstory wall greater stiffness against the important effect of the wind.(On the architectural treatment of the flying buttress see farther on under the development of the elevation of the church).

Line of pressure in the middle pier under the influence of the flying buttress.

If the static conditions of the middle pier of a basilica w with flying buttresses are investigated, there are at first o omitted the roof load and wind pressure, and only for the mass of the masonry with its vaults is made the examination in the frequently described manner by graphics or by calculation. Most favorable will be the course of the force when the middle line is always closely attached to the middle axis of the wall or of the pier. A careful estimate of the masses of the wall and pier as well as of the thrusts of the vault, but particularly the insertion of a correctly determined thrust of a flying buttress at the proper place will lead to the aim. Fig. 408 r represents a favorable transfer of force under ordinary conditio

The thrust of the flying buttress is somewhat less than that of the vault of the middle aisle and is applied somewhat above that . The counter pressure of the flying buttress B_1 is combined at the point 1 with the weight P_1 of the upper part of the wall to the resultant force R1, that is turned toward the inside

of the wall, until at the point 2 the oblique thrust W_1 of the middle vault joins it. The thrust of the vault is greater than that of the flying buttress and therefore turns the resultant R_2 again towards the outside, and at the point 3 combines with the weight P_2 of the part of the clearstory wall concerned into the force R_3, which at the point 4 unites with the thrust W_2 of the vault of the side aisle. It is now of importance, w whether the difference between the horizontal thrust of the middle aisle and the flying buttress is greater than the horizontal thrust of the side aisle,or smaller. If the remaining thrust above were greater, then would the resultant R_4 tend to the outside, but if smaller as assumed in the Fig., then R_4 again tends to the inside and finally combines with the weight P_3 of the pier with the division arch to form the pressure R_5, which at the point U enters the foundation, and after receiving the weight P_4 of the foundation at last passes at the point E into the ground.

Just in the lower part of the pier, where the load has become greatest and the mass is usually most restricted, is desired a position of the pressure as nearly central as possible.

What changes occur by varied attachement of the flying buttress are explained by sketches in Figs. 409 and 410. In Fig. 409 the thrust of the flying buttress nearly equals the thrust of the vault of the middle aisle, and consequently the force R_2 passes almost vertically downward, in Fig. 410 the thrust of the flying buttress of the side aisle together are as great as that of the middle aisle, which leads to making the resultant R_4 vertical below. Farther in Fig. 409 the flying buttress is dropped far down with the result, that the resultant R_2 tends outward, while the high lying flying buttress in Figs. 408 and 410 force the point 2 of intersection back against the vault of the middle aisle.

Likewise as by the position and form of the flying buttress the line of pressure can be pushed in or out, the weight of t the different parts of the wall and its corbelling toward the interior or exterior, and further the weight and ratio of the rise of the vaults, may exert the greatest influence. There a are so many inexhaustible possibilities of leading the line of pressure, that even apparently very developed conditions by t the existence of galleries, triforiums and external passages

may be mostly mastered by correct judgment without difficulty. The flexibility and freedom of the mediaeval method of construction appears in no other place more strikingly.

6. Roof Load and Wind Pressure.

Permanent weight, snow load and wind pressure on roofs. Since the roof load is exposed to great variations in consequence of wind and snow pressures, and since further it sometimes is lacking during repairs for a time, one cannot regard it is a favorable loading, but must first take into account t the stability of the building without regard to the weight of the roof and the wind pressure, then adding both.

Weight of the roof alone.

The weight of the roof is composed of the weights of the trusses, rafters, strips or sheathing and the covering.

The trusses without the rafters but with the roof beams belonging to the construction weigh for light construction 20 to 30 kil, for heavy trusses 30 to 50 kil, and the weight of iron trusses can be taken the same. If complete floors and temporary loads are to be expected, they are to be considered.

The rafters weigh per q m of inclined surface 10 to 15 kil, the strips 5 to 10 kil, and a sheathing of boards 2 1/2 cm thick 20 kil, or one of 3 1/2 cm thick 30 kil.

For one q m of covering material (without sheathing or strips may be calculated as follows:-

Double tile roof, 75 to 100 kil or an average of 90 kil.
Single, pan or grooved tiles, 45 to 65, averaging 60 kil.
Slate roof, 30 to 45 kil, averaging 40 kil.
Metal roof, 8 to 16 kil, averaging 10 kil.

Accordingly the total weight of the roof construction with covering is:-

Covering.	Per q m of roof surface.			Per q. m of plan. Inclinat.		
Kind.	Kil.	To	Aver.	30°	45°	60°
Doub. til.	120 k	175 k	140 k	---	200 k	280 k
Sing. tile.	85	140	110	---	155	220
Slate	75	120	90	105	130	180
Metal	60	95	75	85	105	150

Snow load.

The snow load is computed per q m area of plan and is usually assumed at 60 to 75 kil. But the snow so seldom adheres to stee roofs, that this assumption requires justification there, so

that for roofs over 45° there is only 30 kil per q m of plan, and for roofs of nearly or over 60° no snow load is generally considered. On the contrary on very flat roofs, especially where snow drifts are to be expected, more is to be taken (perhaps 90 or 100 kil in northern Germany.

Wind pressure against a vertical surface.

The maximum wind pressure on a vertical surface is usually taken at 120 kil per q m in Germany. For example this pressure will have to be assumed for vertical walls, gables, and walls of towers.

For particularly exposed places, towers and gable walls, this value is to be increased, perhaps to 150 or 180 kil. C. W. Hase by reference to definite cases warns against too low an assumption of wind pressure. Particularly may a gust of wind produce vibrations of a high gable wall, which lead to its overthrow.

Wind against roof surfaces.

The pressure against an inclined roof surface is smaller. T The wind that strikes against a q m of the surface of the roof (120 sin angle of inclination in kil) is resolved in one direction perpendicular to the roof, and in another parallel to it. The last component is considered as ineffective. The pressure perpendicular to the surface is alone considered and has the magnitude of 120 $\sin^2 a$, when a is the angle of inclination of the roof. For flat roofs instead of a is taken an angle of a+ 10°.

The roof must be constructed with sufficient strength to receive this wind pressure and to transfer it to the support. At present the wind only concerns us so far as it loads the support, and for this purpose it is advisable to resolve it again into two components, indeed into a wind load directed vertically downward and a horizontal wind thrust. These forces are calculated for different inclinations and are collected in the Table.

Vertical Wind Load and horizontal Wind Thrust for 1 q m of inclined surface of the roof in kil per q m.

Incl. a.	Both sup.	Wind. sup.	Leew.supp.	Hor.Thrust.on both
	Vertical wind load on supp.			Supports.
Up to 20°	28 k.	20 k	8 k.	10 k.
30°	43	29	14	25
40°	54	31	23	45
45°	57	28.5	28.5	57

50°	58	23	35	69
55°	57	14	43	81
60°	53	0	53	92
70°	40	-45	85	110
80°	21	-152	173	118
90°	--	---	---	120

The distribution of the horiontal wind thrust to the supports cannot be stated in general, since it depends on the character of the construction.

For iron construction is usually fixed one support, the other being made movable (by rollers etc.); in this case the fixed support must alone receive the thrust for both directions of the wind, while the free one at most can receive a portion corresponding to the resistance of friction. For firmly anchored roofs it may be assumed for greater safety, that the wind thrust is in the most unfavorable way received by the left or the right support. Otherwise one would also not err for similarly fastened and moderately steep roofs in dividing the horizontal wind thrust between the supports in the same proportion as the vertical wind load.

In the distribution of the vertical wind load to the supports as given in the Table is assumed a gable roof; if this is flat the load on the windward support predominates; at 45° both supports have an equal share, and then the leeward one has more, until for more than 60° of inclination, the windward support is relieved and the roof must be prevented from overturning by its weight or by anchoring.

For shed roofs both supports receive equal vertical wind loads if the higher end lies directly above on the plate. On the contrary if the upper end is supported by intermediate construction, so that both supports are at the same height, then already at 45° of inclination the windward support has no longer to receive any vertical wind load, and with a greater inclination an overturning moment is formed under the wind pressure, opposed to which is the moment of stability of the weight of the roof.

Example. The middle aisle of a basilica with 12 m width and 7 m length of bay is covered by a slate roof of 50° inclination. The loads and thrusts of the roof on the side aisle piers are to be determined with and without wind.

Ordinarily each pier supports only the permanent weight of the roof over half a bay; with 9.4 m inclined length this has a surface area of 9.4 × 7 = about 66 q m. The weight of the framework and covering of the roof is 90 kil per q m (p.182); then on a pier rests a permanent load = 66 × 90 = 5940 kil.

If a snow load of 30 kil per q m of plan be added, this = 7 × 6 × 30 = 1260 kil.

The wind causes a perpendicular pressure on each q m of exposed surface of 23 to 35 kil (see Table), and thus the windward pier receives 66 × 23 = about 1520 kil, and the leeward pier receives 66 × 35 = 2310 kil. The maximum roof load with snow and the strongest wind (that moreover can scarcely occur together) would then be for the leeward pier of the middle aisle increase to 5940 + 1260 + 2310 = 9510 kil, while the windward pier might receive 5940 + 1260 + 1520 = 8720 kil.

More important is the horizontal wind thrust, and according to the Table it amounts in this case to 69 × 66 = 4554 kil. E Even if it be assumed that this thrust is almost equally divided, so that only about 2500 kil needs to be taken for one side, this is not entirely unimportant at this height, and it deserves consideration in the static investigation of the pier, unless as hereafter shown, care is taken to add a buttress system for it.

If it concerns the wind pressure against the roof of a hall churchor one of a single aisle, then the wind thrust at the w windward side will partly equilibrate the thrust of the vault, thus reducing the load on the support, but at the leeward side the wind thrust is added to the thrust of the vault, and therefore for large and steep roofs, this is to be taken into account in determining the buttress or thickness of the wall, which presents no difficulty.

When the middle pier of a hall church or two aisled church does not support any roof load, then it will not be essentially affected by the wind thrust. But if a part of the roof rests on the middle pier, it depends entirely on the mode of construction how this participates in receiving the wind and roof loads. If it is shown by static investigations (according to the earlier examples on p. 154 and 157), that the middle pier receives the wind thrust sometimes from the right and sometimes from the left and cannot resist without an undesirable increase

in dimensions, it is very advisable to build a stiffening of masonry over the cross arch in a transverse direction between the walls, with this transfer of the wind thrust to the external walls.

Pressure of the wind against the walls of the basilica.

Very powerful is the pressure of the wind against high wall surfaces, for single-aisled or hall churches it is usual to build the external walls with their buttresses so strong that the side struck by the wind can receive the pressure itself. Only for very great heights will one have to take in consideration, to transfer part of the wind pressure above the vaults to the other external wall and can join it to the thrust of t the vault.

Wind pressure and vault thrust

But for the clearstory walls of the basilica, that are to be supported on as slender piers as possible, the mastery of the wind pressure belongs to the most important questions, and as will be shown later, it may even become more important than that of the thrust of the vault, it is striking that the importance of the buttress system for the movements of the wind has received so little consideration before.

The clearstory wall of the great cathedral rises 15 to 20 m or more above the side aisle. With 7 m width of bay and 20 m free height, for example there would be presented to the wind 140 q m of surface in each bay, which would receive a pressure of 140 × 120 = about 17,000 kil, aside from the wind thrust of the side roof, which perhaps also exerts 2000 kil on the clearstory wall and the thrust on the middle roof, which with the magnitude of 5,000 to 8,000 kil carries a greater or smaller part to the wall considered. Therefore the surface of each bay of such a basilica receives a wind thrust of 20,000 to 25,000 kil, and even a greater amount is calculated for the cathedral of Cologne. But now a vault over the middle aisle of 70 to 100 q m area in plan (7 m length of bay and 10 to 14 m span) with compartments vaulted one brick thick or with a like weight of natural stone, according to Table I (p. 135) only exerts a thrust of 15,000 to 20,000 kil on each wall. The vaults must therefore be kuite heavy to produce a thrust that equals the maximum wind thrust to be expected.

For the mastery of the wind thrust are two possibilities, e either the stability of the clearstory wall concerned or of its piers suffices to receive the thrust, or the wind thrust must be entirely or partly transferred in or over the vaults to the other wall.

Wind pressure on the basilica without flying buttresses.

The first case, the reception of the wind by the wall concerned itself must occur in a basilica without flying buttresses, since a transfer to the other wall would increase the thrusts of the vault, to oppose which in the basilica without flying buttresses would already cause great difficulties. The leeward wall would already be stressed sufficiently more if it could safely receive the part of the wind thrust of the roof falling to it.

If in a basilica of medium size and without flying buttresses each middle pier receives a vertical load of 300,000 kil, and the entire wind pressure against the clearstory wall with its roof is calculated at 10,000 kil with an average height of the application at 16 m above the base of the pier, then this wind pressure would notably move inward the line of support in the pier at bottom, indeed by a distance x, which is very simply calculated by the equation of moments:-

$300,000\ x = 10,000 \times 16.00$, so that $x = 0.53$ m.

Accordingly by the wind is to be expected a movement of the pressure of about 53 cm at the bottom. If this movement occurs within the limits of the kern, then can the pier ordinarily, i.e. without wind, can receive the pressure in the outer angle of the kern and have dimensions for a rectangular plan of $3 \times 0.53 = 1.59$ m or of $4 \times 0.53 = 2.12$ m for a circular plan.

Then would the edge pressures already be quite important, so that for weaker material these dimensions would have to be still increased. (Without wind pressure by balancing the masses the pressure to be conducted through the middle of the pier, and thus would remain within lower limits, and also the dimensions of the pier could be made correspondingly less.

It is evident that for moderately high basilicas with low middle aisle in all cases the reception of the wind by the wall struck by it is yet possible; but when in the 12 th and 13 th centuries the proportion of height was considerably increased without increasing the loading mass of the wall, or it

was even sought to lessen the latter as much as possible, then the middle wall could no longer satisfy this requirement, and otherwise in consequence of the vibrations of the wind the lower dimensions of the pire must receive an enormous increase, that men sought to reduce first of all.

Wind pressure on the basilica with flying buttresses.

For example of a basicila with a load of 300,000 kil on the pier receives a wind thrust of 20,000 kil applied at 25 m above the floor, then would the wind produce a change in the line of pressure of $x = \frac{20,000 \times 25.00}{300,000} = 1.67$ m. But in such a basilica one could not make the entire pier so thick. For this example based on only average proportions it is evident, that the middle pier of a very high basilica could receive only a very small part of the wind pressure, that the principal portion must be transferred in or above the vaults to the other side and must be received there in a suitable manner. But since the wall can even less receive in itself, the addition of the flying buttress becomes a necessity. There may be established here the statement, that the introduction of the flying buttress was required just as much by the wind thrust as by the vault thrust. Only from this point of view can one understand fully and entirely the construction of the ancients, and first in it is recognized the purpose of the flying buttresses set doubled over each other; the upper one being usually applied much higher than is required by the wind thrust.

To illustrate the effect of the wind thrust it is drawn in Fig. 411 (cross section of the minster at Strasburg), the position of the lines of pressure with and without wind pressure, the first being dotted and the last in broken lines. The course of the action of the wind from the left is as follows.

1. The wind exerts on both walls a thrust directed to the right. 2. In the clearstory wall struck by the wind and its piers the line of pressure is moved somewhat to the right. 3. The left clearstory wall then leans somewhat to the right. 4. In consequence of this leaning of the clearstory wall the flying buttress at the left side is somewhat relieved (line of pressure is more curved). 5. By this leaning the left clearstory w wall lies against the vault of the middle aisle and causes a greater transverse stress in this, which is transferred in flatter lines of pressure through the cross arch and the upper

part of the compartment. By the greater pressure of the vault the right clearstory wall is somewhat inclined, thereby moving the line of pressure in it and in the pier beneath it somewhat to the right. 7. The flying buttress at the right side receives greater stresses by the leaning of the walls, which produce straighter lines of pressure. 8. In the external buttress at the right the line of pressure is moved to the right in consequence of the greater thrust of the flying buttress.

One must regard the entire system as movable, in spite of t the rigidity of the materials there exist little elastic movements, even if they only measure mm, which cause no injury in the joints of the masonry within these limits. The weaker parts are first moved somewhat and the stronger parts less; if a stronger and a weaker part of the construction have to participate in this work under similar conditions, the stronger will accordingly take the greater part of the work upon themselves.

For example if the middle pier below is very slender or is placed on a ball joint, then the middle wall would swing with the least excess of thrust from right to left, and would lean against the vault or the flying buttress, transferring there the entire thrust without carrying any downward. Conversely if the middle pier were very strong and the upper pressure were very weak or entirely absent, then would the pier carry the greater part or the entire thrust to the ground. Accordingly within very wide limits were men able by skilful arrangement of the construction , to cause either the middle pier or on the other side the external buttress with its entire system of transverse pressure, to carry more of the thrust.

But they would make the middle pier as thin as possible, and therefore they transferred to it as much as possible only vertical loads of moderate size, and on the contrary must the thrusts and especially the varying side movements be kept from it as far as possible, and for these entered a buttress system so much stronger.

But the resistance of the buttress system is produced less by piling up masses, than by their correct arrangement. Already it is shown by the flying buttress that its stiffness can be obtained by a corresponding form, and that it may otherwise be quite easily obtained.

Transfer of wind pressure through the vault.

An important limit in the chain of transverse stiffening is f formed by the vaults of the middle aisle, to which falls the task to transfer the varying thrusts, and it is advisable to briefly consider the vault on the ground of its function. That the vault may transfer a greater thrust, or the same thing, c can receive a greater sidewise stress, there must be formed w within it flatter lines of pressure than usual, for otherwise under the greater pressure the crown would be raised and it would eventually be destroyed, and for this reason a light tunnel vault would be little suitable for transverse stiffening, while an equally light cross vault might be able to undertake this by the peculiarity of its form.

The vault can generally maintain itself in equilibrium only if the external forces, that act on it sidewise are exactly as great as the thrusts exerted by the vault outside, since in general a condition of rest can only be conceived, when force and counter force everywhere neutralize each other. If the stressing force is too great, the vault is forced upward, but if it is too small, then would the vault press downward. Usually the thrust of the vault is neutralized by the opposed counter pressure of the abutment, which is to be regarded as the stressing force for the vault. If the wind pressure is added at one side, this joins the opposing pressure of the abutment to form a greater counter pressure, that must be opposed directly by a greater thrust of the vault, if equilibrium is to be preserved. A vault can with a permanent loading exert a greater thrust only if flatter lines of pressure be formed within it. But this greater thrust not only acts at the windward side, but also at the leeward side, where it must be opposed by the counter pressure of the abutment mass, and indeed mostly by a flying buttress.

In unfavorable conditions the thrust received by this flying buttress on the leeward side is increased to the sum of the ordinary vault thrust, and the wind pressure against the clearstory wall with the entire wind pressure against the surface of the roof. But it will usually be stressed less, since the middle pier takes a part of the stress on itself.

As previously stated, a tunnel vault is little suited to transfer the wind thrust, since in it the lines of pressure have little play, and then the vault must be very thick, have a ba-

backing, and moreover being so heavy and having such great thrust, that the wind pressure is relatively small in comparison to the vault thrust itself. Quite otherwise is it for the cross vault, even if its compartments are very thin, and the cross arch must have a deeper cross section in which flatter lines of pressure are possible; but this is not the only way, the cross section of a cross vault is horizontal on the middle axis or is always rather flat in a raised vault, and in this upper part of the cross vault can be formed flatter lines of pressure, here is a transverse stress on transverse shoring is possible, if one prefers, as indicated by lines in the cross cross section of Fig. 411 and in plan in Fig. 412. What the cross arch with its backing cannot undertake must the ridge of the vault take on itself. The wind pressure transferred by the ridge of the vault acts at c d on the opposite side on the wall and seeks to bend it outward, which must be opposed by by its stiffness, it acts like a horizontal arch in plan and transfers the pressure to the supporting points e and f. Here must be attached the flying buttress to receive this pressure. Therefore the problem is solved, wherefore very many flying buttresses stop close beneath the eaves of the roof. Naturally must a flying buttress be applied far higher and not be too h heavy, so that it may not ordinarily press the wall too strongly inward. Since it is also concerned to receive the vault thrust acting lower, the flying buttress must join it with a high vertical surface (Figs. 403, 405). If this surface be too high and the arch be undesirably heavy, it is better to employ two in its place, a higher one that chiefly serves to receive the varying wind thrust at the ridge of the vault according to Fig. 412, that strongly tends to bend the leeward wall e f, and therefore this is not to be too thin over the windows; in old examples it has been skilfully made thicker by corbelled arches outside and inside, and made more resistant by heavy gables.

Stiffening by cross arches.

This stressing of the wall may be entirely or partially avoided, if the cross arch is made sufficiently stiff and is suitable to thereby transfer the wind thrust instead of the ridge of the vault, as the section in Fig. 413 indicates at the right and left in two places. It must now transfer the pressure from

the wall struck by the wind to the points a and b, which is h here easily possible, since this transfer is distributed over the entire height and besides the pressure here opposed in direction to the vault thrust is less injurious. Thereby the variations would be kebt far from the middle part of the vault and further would receive in the plane of the cross arch a strong closed buttress system, the one great arch as if extending from the ground at the left through buttress, flying buttress and stiff cross arch over to the right even to the base of the buttress. Whether stiffening the cross arch in the perforated manner of Fig. 413 as executed in the historical examples is unknown at this time, a good backing of the spandrels and of the lower springing of the cross arch is also executed in the same little shafts. --- One can frequently observe, that the ancients had arranged at proper places loadings of cross arch, which modern times have removed from ignorance.

It should also be mentioned, that the roof beams could take an essential part in the transfer of the wind thrust and in the entire transverse stiffening, and in many cases did in fact. At least they are suited to transfer to the leeward wall and the flying buttress there the entire wind thrust of the roof as soon as the windward wall inclines only the least; this is then possible even when they are not firmly fastened to the wall but merely placed against it (By the friction on the pearing surface).

Bending of clearstory wall.

In closing, another effect of the wind on the clearstory wall is to be emphasized. A high wall will tend to bend in the part between the side aisle and the vault of the middle aisle in an entirely similar way as a board standing vertically bends under a side pressure. Fig. 414 I represents the scheme of the d distribution of the stresses in the cross section of the wall pier.

The magnitude of the stresses is computed by seeking the bending moment in the same way as for a loaded beam with a single difference, that the latter lies horizontally while the wall pier stands vertically. In the same case the bottom end of the pier is to be regarded as one support (regarded as fixed) and the upper end of the wall at the vault as the other support. The maximum bending moment will be expected at a certain height

above the roof of the side aisle, but nothing,will be added o concerning the simple mode of seeking it, as this reference to this effect of the wind and the final conclusions to be deduced from them may suffice.

To the tensile and compressile stresses of the cross section represented in Fig. 414 I are joined those of the wall and pier pressure D produced by their upper loads (Fig. 414 II). If D passes straight through the centre of gravity of the cross section, it produced uniformly distributed compression. The stresses in I and II are added together algebraically, so that the total stresses in the cross section are shown by Fig. 414 III. At the outer edge are added the compressions of I and II, and at the inner edge is the difference of tension and compression. If the tension is here greatest, an excess of tension would remain as shown in the Fig. The last is avoided and the entire distribution of the stresses is more uniform, when the compression D is not applied at the middle but nearer the inner edge as illustrated by the corresponding representation of the stresses in Fig. 415.

Thereby the wind pressure against high clearstory walls is made desirable, to keep the line of pressure in the upper half of the wall nearer the inside, but for the lower part of the pier it is better for similar reasons to keep the compression far from the inside; therefore the course of the compression as in Fig. 410 is designated as favorable. But according to t the statements on p. 161 this can be attained by a flying buttress attached not too low and not pressing too strongly. Two flying buttresses above each other again act better and will further hold the top of the wall more safely, so that it assumes more the properties of the end of a firmly fixed beam.

Likewise this bending effect of the wind on the clearstory wall is not to be underestimated, for it is so important in t the great cathedrals, that the cross section of the wall or t the wall pier is so correctly dimensioned as to receive it with sufficient safety. That the powerful wind pressure against the great surfaces of the windows likewise demands great consideration, and is also found in the mode of construction, is only incidentally mentioned here.

If the restricted space did not forbid, we should gladly follow the effect of the wind on the buttress system farther, the

more because within our knowledge nowhere else is sufficient consideration given to it. In any case this consideration only serves to enhance the high esteem of the old masters; the more one penetrates into the details of their construction, the more he leamns to wonder. --- Our modern timer have brought forth nothing in the domain of masonry construction, which in boldness of thought ayd in grandeur of structural conception can be approximately compared to those works of the ancients.

III. PIERS, COLUMNS AND CORBELLINGS.

1. Construction of Piers.

The function of the pier consists in transferring the load of the arches and vaults to the foundation.

This foundation is formally expressed in a twofold way, and accordingly is determined the difference between the compound pier and the single column.

The pier transfers the multiplicity of the springings of vaults to the simple square of the foundation, when it gathers the different more or less richly moulded arches by means of the capitals into certain groups forming the members of the pier, the latter then expressing a later simplification and extension by the base, and thus resting on the foundation generally appearing in its original or modified form.

On the contrary the column is the simple support without tendency. Its shaft forms an insertion between the foundation and capital, it carries in a certain sense the foundation up to t the weight of the springings of the vaults, where it repeats these in a simple or modified form in the abacus of the capital

Both modes of treatment find their origins in antique art, from which come the Romanesque, developed them according to t their needs and presented them to the Gothic.

If the support had to serve a relatively simple purpose, if it had to bear a beam ceiling, an arcade or even the similar vaults of a room like a hall, then its entire development was made quite simple and regular. On the contrary if combined requirements existed, were they vaults of adjacent aisles of different spans and separated by broad dividing arches, perhaps also even of different heights and supported by the pier, then was there opportunity for inexhaustibly varied solutions, which the middle ages places before one's eyes in ever novel transformations from the Romanesque period downward.

The form of the compound pier already in the later time of Romanesque art and in the transition style to a superior richness of development, which the Gothic art of the 13 th century found something to add, only because the vaulting system and therefore also the plan of the springings of the vaults had assumed a more complex form.

The subdivided angular pier.

Projections from the pier.

The Romanesque pier first consists of a square nucleus, that has to support the dividing arches between the aisles, and then the various projections that stand beneath the cross and diagonal arches of the vaults of the middle and side aisles. (Figs. 416, 417). When the depth of the dividing arches became so great that they had to be composed of two concentric rings, and therefore their cross sections assumed the form shown in Fig. 418, the plan of the nucleus must also have a more complicated shape, where it either follows the profile of the dividing arch, or receives the addition of a projecting half column, which by its capital passed into the square form a b c d of F Fig. 419. The projections toward the aisles could then best h have the same plan, while the diagonal rested on the square angles and the cross arches came on the half columns, so that the plan of the pier assumed the form of a Greek cross with p projecting half columns before the ends of the arms (Fig. 419, left). The next addition resulted as soon as instead of the groin arches actually projecting diagonal arches were admitted, that on the one hand had no proper bearing on the angles of t the arms of the cross, and on the other hand the cross arches seemed to demand corresponding projecting columns. Accordingly there resulted the form shown in the right half of Fig. 419. If the projecting half columns were originally semicircular, then since consistency thus required that under the diagonal arches there must be quadrants, which could form no sufficient bearing. Forst must the latter have a larger portion of the circle, and then also those projections from the surfaces must exceed the semicircle. The separation from the nucleus thus obtained, the independent effect of these parts removed them from the character of half columns, and therefore from now onward even this name became unsuitable.

Bonded and attached shafts.

In the language of the mediaeval stonemasons these little c columns received the name of bowtell (dienst) and this expression is recommended by just its definiteness and exclusiveness. The bowtells or shafts are either fully bonded with the nucleus of the pier, so that the separate courses of cut stone extend through the entire form of the plan, or they are attached to the nucleus of the pier, so that they are connected to it only by the capital and base, or sometimes of greater height are

also joined to it by the so-called bands.

The independent shafts consist of tall cut stones set on end and not on bed,which surround the nucleus either free, so that spaces remain, or are in contact. The bands form concentric m mouldings, that are bonded in the nucleus, and thus retain the attached pieces in their positions as in Fig. 420. But sometimes they are not expressed at all and then form only a lower bonded course. The latter arrangement is chiefly peculiar to the developed works of Gothic art, while the former is common in the works of the transition style, yet also reappears in certain early Gothic works.

First is the material on which depends the choice between the two methods of construction, of the banded or independent shafts; for the stone must be of the most uniform and fine grain to permit its being set on edge. But even the same material in different works in the same city and only separated by a brief time, as for example the churches of Notre Dame and of S. Benigne in Dijon, we find in the first independent and in the last bonded shafts, and both modes of construction have been retained for almost six centuries. In certain German churches, as in Wetter, are found both methods of construction connected together; while elsewhere in Germany the bonding of the shafts is the general arrangement. Experience also seems equally favorable to both.

Which of the two solutions stands higher esthetically is indeed only to be decided in each case, and it is to be added, that in some remaining examples the pier was colored and then over the nucleus extended white beds, but the shafts were left free and thus represented monoliths in a certain way, as for example in the former painting of S. Elisabeth's church in Marburg and in the church in Wetter. The most extended and spirited treatment of the construction of attached shafts is found in the Article Construction by Viollet-le-Duc.

Multiplication of shafts.

The form shown in the right half of Fig. 419 is found almost unchanged in certain Gothic works, as on the crossing piers of the church at Haina and of S. Blasien in Mühlhausen, where the plan of the nucleus becomes that of a regular Greek cross, so that the arms of the cross with the projecting shafts suggest the dividing arches, and t the shafts standing in the angles of the crossbear the diagonal

arches (Fig. 421,left). Accordingly there still remains visible of the nucleus of the pier the angles under the upper ring of the dividing arches. But men soon began to extend the adopted principle also to these angles of the pier, i.e., to open these by a rectangular cut and to place in the latter a shaft in the same way, as a similar one was already found in the angles between the arms of the cross, and thus they passed to t the form represented in the right half of Fig. 421. In a certain respect the last is also found already in those Romanesque forms of piers, where the rectangular angles were divided by inserted shafts. But while these little columns beneath the c capital of the pier and above the base of the pier passed into the right angle, this transition is omitted on Gothic piers a and each separate shaft has its own capital, its separate base, and both parts entirely enclose the nucleus, yet its edges are still visible between the shafts.

An ordinary aisle pier treated according to this principle would therefore consist of 12 shafts, one of which supported each cross rib, as well as three supported each dividing arch. Since in early Gothic works the cross arch is lower than the diagonal rib, and also the lower ring of the dividing arches freely projects and is likewise larger than the portion of t the upper ring visible over it, these shafts support also the arches mentioned, and thus the shafts in the axes of the plan of the piermust be larger than the others. Now to make the entire form entirely regular, the larger and smaller rounds could be assumed equal, although such regularity is not based on the nature of the thing. According to this system are treated the main piers in the collegiate church in Mantes.

Treatment varied in both directions.

The number of shafts always increased according to the number of the arches. Thus in the nave of the cathedral at Rouen, the division arches consist of three rings, so that a b in Fig. 422 represents half of a cross section of a dividing arch, which therefore requires five shafts on each side, and the entire pier is composed of 16 shafts. While they stand beneath the dividing arches in the ordinary way just as in Fig. 420, they are connected with the nucleus and appear to indicate an entirely regular form of the whole, the arrangement is according to that of the aisles, yet the shafts bearing the vault ribs become ay-

entirely different. The reason may be sought in that it was unsuited for the springing of the vault to project the cross rib so far. To avoid this projection lay nearest the right angle of the nucleus, that in a certain sense determined the position of the shaft, was omitted and then was given a prominence to the shafts suited to the need. Since by this was already g given up the regular form of the plan of the pier, there was no further reason in regard to the diameter of the shaft for requiring a uniformity not based on the nature of the matter. Thus in Fig. 422 the shafts supporteng the lower ring of the dividing arch, that also came to lie on the longitudinal axis of the piers, is greater than that lying on the transverse axis and supporting the cross rib, so that the entire plan of t the pier received an indeed symmetrical, tough no longer concentric but extended form in the direction of the length. More decidedly prominent appears the proportion of length in the piers of the Cross church in Breslau.

That in general the nature of the matter did not afford concentric symmetry is most clearly evident by the cases in which, where by retaining the regular plan a special arrangement of the forms of arches was allowed, which then led to an irregular section of the dividing arches. As examples we mention the nave cross of the minster at Strasburg aod at Freiberg -i-B; Fig. 423 shows the plan of the former. Men started from the principle that the dimensions of the vault ribs depended in the span of the vault, so therefore the cross arches and diagonal ribs of the middle aisle must be larger than those of the vaults of the side aisles. The piers themselves consist of eight large shafts standing in the axes of the diagonals of the plan of the pier and eight smaller shafts between them. While now the cross ribs of the vaults of the side aisles rest on one of the larger shafts, according to the preceding principle those of the middle aisle require three, thus a larger and two smaller ones. According to this while the cross ribs of the side aisle stands on a smaller shaft, those of the middle aisle are separated by those larger ones standing in the diagonal, and could also again have the proper proportion of dimensions. According to this there also remain four shafts for each dividing arch, which therefore prescribes for them the form seen in Fig. 423, so that their cross section toward the side aisle consists of

three, and toward the middle aisle of two rectangular corners. The same propoftion is found in the minster of Freiburg.

In the enclosure of the middle square of the cross and further in the piers supporting the inner angles of the towers is found the converse proportion, while here the equality of four dividing arches resting on the pier and four diagonal ribs also leads to a regular plan of the pier.

Treatment of the nucleus between the shafts.

The form of Fig. 422 also shows many partly very characteristic peculiarities. Thus the shafts are partly joined to the nucleus of the shaft by a neck, i.e., by a part bounded by straight lines and recessed at the back. This arrangement has t the advantage that the effect of the shaft becomes bolder anf by the freer position results a large space for the development of the capitals. A richer form is further given thereby, that between the shafts the still visible surfaces have moulded chamfers, which die beneath the capitals of the shafts and at the height of the base of the shaft pass into the square by a stop chamfer. However in this form are also expressed the stepped form of the nucleus by the square angles. But how the latter were left in regard to the shafts next the aisles has already been shown above. They stop entirely to be perceptible to any one, as soon as the right angle is rounded at d, and thus the shafts are connected together only by hollows, as for example those opposite the same piers and forminm the entrance to the shapels arranged between the buttresses exhibit shafts. In the example mentioned the two forms are indeed separated by a century. But they stand still abruptly and at intervals of perhaps scarcely a decade opposite each other in the aisle piers od Strasburg and Freiburg. While as evident from Fig. 423, the first exactly follows the old system, in the latter the otherwisi similar in number and style rounds are directly connected by hollows as given in the upper quarter in Fig. 423 by dotted lines. Men appreciated little the nature of the matter for such rich piers, and only from a distant similarity introduced clustered piers with an expression brought from a foreign object.

The development of the middle and later periods belongs to freer forms of piers, of which Figs. 437 to 440 afford examples, and we shall describe them later.

The round pier and its members.

Round pier without little shafts.

We have sought above to designate the nature of the single round pier, that reproduces the form of the foundation, which appears in the abacus, rises to the height of the springings of the arches and in a certain way must form an intermediate between the two. Whether the entire arrangement of the Gothic round pier originated from the Romanesque column, or the growing Gothic art gathered again the many members of the Romanesque pier into a unity, to attempt ti divide it in a new way, is a question unimportant to our purpose. On early Gothic works in Germany is found but seldom the simple round pier, but therefore the more common is it in France, and there occurs from the end of the 12 th to the middle of the 13 th centuries both exclusively in entire rows, for example in Notre Dame at Paris and at Dijon, as alternating with compound piers in the arrangement of the hexapartite vaults,so that the compound piers receive the cross and diagonal ribs, the round piers bearing the bisecting rips.

According to what was said above, the square form of the abacus of the capital is nearest, at the same time also best corresponding to the original shape of the cut stone. In such wise terminate the round piers of the cathedrals of Paris and Laon in square and slightly rounded capitals. The great projection obtained by such capitals, especially when seen diagonally, c contributes no little to their stately and solemn appearance, affording opportunity for the arrangement of rich and bold ornament. To the much subdivided form of the springing of the arlhes least corresponds the simple square form. Therefore it must yield to other basal forms, first to the regular octagon, when the principal of the compound pier passed to the round pier, and the form of the springing of the arches determined that of the capital of the pier. Yet any regular form of the abacus introduced everywhere difficulties and restrictions, w where the direction of the dividing arches deviated from the simple straight line or those intersecting at right angles, as for example is the case for avery polygonal choir enclosed by an aisle (Fig. 424). The French works indeed now show frequently solutions of these difficulties only effected by a modification of the basal form of the abacus, to which we shall later

return, yet the simplest and nearest means might be found in this, that the pier being connected with one or more shafts according to the plan of the Springing of the arches, abandons the regular ground form and assumes one corresponding to its function.

Round pier with little shafts.

An example of this kind with greater consistency is shown by the round pier in the polygonal choir of the cathedral at Meaux. (Fig. 425). It supports on an irregular capital of octagonal form adapted to the decagonal shape of the choir the dividing arches, the cross and diagonal ribs of the vaults of the choir aisle and the round a, on which rests the side arch of the choir vault. On the contrary the diagonal ribs of this vault are borne by the rounds b, that extend from the ground and are connected with the cylindrical pier by flat hollows in which intersect the capital beneath the dividing arch, cutting as shown by the perspective view of Fig. 425 a.

But also for the piers separating the aisles, the peculiarities of the arch system have led to similar forms of piers entirely differing from the square basal form. Such an example is offered by the collegiate church at Mantes, whose vaults a are hexapartite. Fig. 426 exhibits the basal forms of the weaker pier from which spring the bisecting ribs. Here the cylindrical nucleus bears only the dividing arches, yet at the side toward the aisle is connected with three rounds, so that the side next the side aisle bears its cross and diagonal ribs, b but that toward the middle aisle supports the bisecting rib a and the side arch. A like arrangement is shown by the piers of the almost still Romanesque cathedral at Besancon, thoroughly changed by later alterations. Here also extend over the middle aisle the usual oblong cross vaults, so that the rounds toward the middle aisle have the same function as those of the side aisle. The ground form differs from that of the pier at Mantes only in that instead of the rounds being connected by flats, they are joined to the cylindrical nucleus by hollows. Undeniable are the clearness and consistency of such an arrangement. This could be transformed in a very suitable manner, according to the arrangement found in the minster at Strasburg of larger ribs in the vault of the middle aisle, if to the side of the nearly cylindrical nucleus toward the middle aisle were added

three rounds, with only one on that toward the side aisle, from the latter spring the cross and diagonal ribs of the side aisle while the larger ribs of the middle aisle would each be borne by a separate round, or if toward the side aisle are found th- three with five rounds next the middle aisle.

But just as well as for the nave piers is the plan of the s springings of the vaults harmonized with a regular placing of the rounds in the most varied manner.

Round pier with four similar rounds.

Thus is formed a pier continuing through the earliest and middle periods of Gothic art, occurring just on the noblest w works that the combinations of the cylindrical nucleus with four rounds set on the axes of the ground form. However simple is this form in itself, the most trifling modifications in regard to the proportions of the diameters of the rounds and that of the cylindrical nucleus, producing so varied an effect. On the older works, as in the Hessian churches at Marburg, Haina and Wetter, then in the French cathedrals of Rheims, Amiens a and Dijon, the rounds are relatively larger, their centres project more strongly, their bodies are usually separated from t the nucleus by a flat band, and the effect is correspondingly vivid and bold. In the churches at Friedberg and Frankenberg, in the nave of the church at Wetzlar, their diameters already diminish and the centres are nearer the circumference of the pier; still greater is the reduction in the church of S. Stephen at Mayence, whereby in spite of the great diameters of the rounds is produced a feeble and less tasteful effect. This defect is even increased by the slight projection of the base, the small importance of the abacus of the capital, the small scale of the foliage on the same, in brief the difference of the latter from those mentioned before is very striking in spite of the similar basal form. Much varied is further the relation in which a pier of this form stands to the springing of the arches.

According to the older system the rounds toward the aisle bear only the cross arches, thosestanding on the longitudinal axis support the lower rings of the dividing arches and the nucleus carries the upper rings of the latter as well as the diagonal ribs. This arrangement is first found in connection with the arrangement of aisles of equal height, in all the

Hessian churches mentioned and the older Westphalian. In modern times this arrangement has been frequently and incorrectly termed as still undeveloped.

Generally such designations are almost as common for the treatment of the forms of early Gothic works, as those of the degeneration, rottenness and drynes for the works of the late period. Both kinds of treatment of form are not to be judged so superficially. Both form only the expression of the structural system of the works concerned. But the latter require in each separate case very thorough investigations in order to be understood, researches to which one must bring not only good will, but also favorable opportunities and some experience in construction. But in the cases it should be assumed, that such an investigation must lead to the avoidance of the before mentioned striking expressions.

This arrangement of the springings of the arches mentioned above on the round pier connected with four shafts is already based first on this, that section of the pier itself in order to resist the excess of the vault of the middle aisle against that of the narrower side aisle, requires one of a diameter exceeding the breadth of the dividing arches, thereby forming an excess of bearing area, which of itself leads to the receiving of the diagonal rib (see the right half of Fig. 427). Besides this reason taken from simple practice, also others derived f from the nature of the matter lead to this arrangement. The entire vault is divided into bays by the cross and dividing a arches. To form these divisions first suffice the lower rings of the dividing arches. Therefore the latter are parallel to the cross arches (?), and in the older works generally have the same profile as those but project more, and therefore were borne by rounds set on the axis of the pier. But the cross ribs most clearly express the character of the Gothic vault, and according to the location of the beds in the compartments the g greatest part of the thrust of the vault is transferred to the pier, thus representing the proper force of thrust. But strengthening by the upper ring of the dividing arch is necessary to represent the wall resting on the dividing arch, whose load together with the roof construction resting thereon increases the resisting force of the pier. Hence justly the nucleus of the latter bears the cross ribs that denote the separating force,

and those increased dimensions of the dividing arches that on the contrary increase the resistance, while the rounds again support the dividing, and the pier the connecting and stiffening arches.

By the partial increase of the springings of the arches certain arrangements further become possible, that again have their reasons in certain peculiarities of the plan. Thus in the church at Wetter the crossing piers are no larger than the nave p piers and are just large enough to receive four dividing arches meeting thereon, so that the diagonal ribs project between the latter and increase with two of those in their base. This location of the diagonal ribs then produces the same stresses, also to retain on the nave piers, so that these with half the p profile increase with the diagonal arches, and between them and the cross ribs are visible a part a b od the face of the compartment in the left half of Fig. 427.

If we so far had in view only the design of piers of this g ground form in churches with aisles of equal height, there is likewise found the same condition in the arrangement of the arches in the design of a raised middle aisle, like the cathedrals of Rheims, Amiens, Chartres, Dijon and as shown on many German churches. In the side aisles the arrangement remains unchanged (see right half of Fig. 427)., but in the middle aisle the round rises above the capital to bear the cross arch above. As a characteristic example is given in Fig. 428 the clear development of a pier from S. Jacob's church at Einbeck (Note) belonging to the 13 th century. The round of the middle aisle is surrounded by a band at the height of the capital, which c continues above the nucleus of the pier and then passes into the abacus of the capital of the side shaft. Above this moulding at each side of the round of the middle aisle, small mouldings on shafts rest on the nucleus of the pier, intended to support above the ribs the side arches of the vaults of the middle aisle. These little shaft members do not find their start on the parts of the nucleus of the pier not used by the dividing arches, since they would otherwise rest on the available border of the capital of a round pier without little shafts.

For the older round piers with four rounds, stated to bear usually only the cross arches, the ribs rested on the nucleus. Later the cross arch and ribs usually developed together from

shaft, and then the nucleus and both side shafts remain for t the use of the dividing arches. As examples may be mentioned S Stephen at Mayence and the Minorites church at Höxter, to the latter belonging the simple development of the pier represented in Fig. 429.

A peculiar arrangement is found in S. Blasien in Mühlhausen. The nave piers as in Wetter are as large as the crossing piers, whose size on their part is determined by the combined four d dividing arches. While here the diagonal ribs start between t the dividing arches, this arrangement is changed for the nave piers, so that between diagonal ribs and dividing arches is inserted a piece of the surface of the compartment, as it appears in Wetter (Fig. 427 left, a b).

In this place is to be mentioned also an alteration entirely favorable in effect in the cathedral at Chartres; for here alternate cylindrical piers with octagonal, and the round ones with four having seven sides of the octagon, the polygonal ones with as many round shafts. (See both plans in Fig. 430).

Note. From the drawing by C. W. Hase at Hanover.

The Crossing Piers.

As already mentioned are found on the crossing piers at the crossing and further at the internal angles of the towers, four arches together having the dimensions of the dividing arches, between which the diagonal ribs must find their bearing. This condition first leads to an enlargement of the pier mentioned (Note), obtained in the most varied ways. By the arrangement of compound nave piers,the crossing piers were subdivided in the same way and only received an increase on the number of l little shafts and the angles of the nucleus, those consisting of about 16 rounds, while the nave piers had but 12. A crossing pier of this kind is shown by the right half of Fig. 421. But even with the arrangement of single cylindrical piers or those connected with rounds in the aisle, the crossing piers are generally subdivided according to the arches resting on t them, thus in Notre Dame at Dijon, and those at the southwest angle of the middle square of the cathedral there, also in Chartres, etc. Simpler forms of this kind are shown by the already mentioned crossing piers of the churches at Haina and Mühlhausen.

Note. Why this enlargement disappeared in the churches mentioned at Wetter, Mühlhausen and elsewhere, will be investigated later.

On the contrary in other works, as in the church of S. Elisabeth at Marburg, the churches at Colmar, at Altenburg, etc., it is found that the relation to the round piers with four rounds in the aisles is there continued in a higher degree, that also the crossing piers consist of a cylindrical pier with 8 instead of 4 shafts, namely 4 larger and 4 smaller rounds connected with the nucleus, whose diameter is increased according to the measure of the plan of the springing of the arches. The tower piers of the church at Colmar are formed according to t the same principle except with an octagonal nucleus.

The most consistent arrangement would then consist in this, that from the plan of the nave pier should be cut out in the lowest part, and from the combination of four such shafts, by the rounds beneath the diagonal ribs, all different parts formed the crossing pier. In this wise with a certain freedom in treatment is constructed the northern crossing pier of the cathedral of Dijon, Fig. 431. Accordingly this combines all elements of the other piers in itself, the circular shape of the nave pier, the rectangular recessions of the opposite crossing pier and a number of rounds corresponding to its function. Sometimes as in the nave of the church at Friedberg, the nave pier still always formed with a round nucleus is combined with 8 rounds, so that a round stands beneath each arch, while the crossing pier is but slightly older and according to its formation is combined with only 4 rounds. In spite of the slight difference in style, chiefly expressed in the treatment of t the foliage, must the increase in the number of the rounds, at least with the retaining of their regular position, must be regarded as contrary to the proper nature of the construction, since the shafts set beneath the diagonal ribs are exactly according to the octagonal division of the circle and restrict the width of the dividing arches, unless the diameter of the pier receives a corresponding increase. Accordingly the increase of the rounds is moderate in the way, that to the plan of the piers of Mantes and Besancon represented in Fig. 426 were added two rounds in the longitudinal axis, or that around the circular pier were set 12 rounds, three each standing under

the dividing arches, whereby the latter received a moderate b breadth without increasing the size of the pier.

This consideration of the size of the dividing arches certainly stops, when the arches supporting the wall are first turned above the compartments and then all formal treatment can be omitted, beneath the compartment but in the same direction is turned a simple rib entirely like the others, so that from each pier starts 8 entirely similar ribs, between which are v visible the surfaces of the compartments in larger or smaller widths according to the size of the pier. It becomes possible by such a plan to place a separate round under each rib, and to attain in general a really ideal regularity, though it still ends in a denial of the nature of the thing, produces the effect of a tiring monotony at least in wide interiors, and is recommended only by its economy, in so far as the arches turned above the compartments and not in connection with them, could be erected with rubble or bricks with horizontal balancing and to support the framework of the roof. This arrangement is found in a relatively still happy form in the nave of the cathedral of Frankfort (Fig. 432).

The exactly similar forms of the ribs, or at least those over the sides and diagonals of the bays, on the contrary is everywhere required by the nature of the matter, where the function of the dividing arches is lost, as for example in vaulted halls, and then in churches composed of two aisles separated by a middle row of piers, which are chiefly found on the Rhine as in Namedy and Bornhofen, but further in the plans of five-aisled churches, for which the rows of piers separating the s side aisles, in brief in all cases, where the ribs extendind in the direction of the dividing arches stand in an exclusive relation to the vaults.

The compound piers of the middle and later times.

Transformation of the members of the dividing arches.

Before we pass to the freer plans of the piers belonging to the middle period, we must examine the corresponding transformations of the profile of the dividing arches. The original and on earlier works almost typical profile of these was directly formed from the rectangle of the cut stone, that is represented in Figs. 423 to 427, already received about the middle of the 13 th century all sorts of additions and a partial transf-

transformation. Thus in S. Blasien in Mühlhausen the rectangle of the dividing arch consisting of but one ring received coves in the corners. A more compound form of this kind is then shown by the dividing arches of the cathedral of Dijon 'Fig. 431), but in both cases in retained the characteristic of the older form, the horizontal underside. Yet the latter disappears when a round is placed on it as at c d in Fig. 433, and the main form of the profile approaches a square set diagonally. The l latter is more clearly expressed if a flat be added to the round as in the cathedral of Rheims. But also the form of the a arch with two rings soon fails to be perceptible, and the joint then separates the lower hollow from the round of the upper ring. Fig. 433 represents these changes. There a b c d is the older and already more richly treated profile, which by the addition of the ogee round in the form a b c f d and by the hollow between the rounds passes into the form characteristic of the middle period.

In the addition of the round or rather of the ogee member of the lower flat and the basal form of the diagonal square thereby obtained for the entire profile, it has been desired to recogniqe after the example of Kugler the form characteristic f for the best period of Gothic architecture, and to include that earlier one with horizontal underside with the still undeveloped transition forms, to which would accordingly belong the greater number of the standard French cathedrals, also the cathedrals of Strasburg and Freiburg in Germany as well as the church of S. Elisabeth in Marburg .nd numberless others. A certain narrowmindedness seems to us to lie in this. So pleasing is the effect of a dividing arch treated in this later form, that it manifestly elevates the difference between the character of a strong dividing arch supporting a wall and the diagonal rib only bearing the light masonry of the compartment. For the profile of the latter is first important the height, while the dividing arch must first have the breadth to receive the wall. The change of the underside into an angle ends directly in the denial of the breadth and also produces in reality the corresponding effect. Conversely we might give the preference to the older form and also prefer a correspondingly simplified shape for the cross arches, as soon as the latter generally b became larger than the diagonal ribs (see the right half of

Fig. 427). The profile a g c f d of Fig. 433 further emphasizes the separation of the two rings of the arch, and therefore is first only in place where the limited dimensions make possible the form of the divided arch with one ring.

But the prominent eeffect of the arch profile ending beneath in an angle asserts in general its right, that it was retained for all richer designs in the late time, and only suffered in the details of the profile certain changes corresponding to t the general character of the period. Thus care was taken first to enhance its character to greater richness by the increase of members, by fillets or roundings inserted between the rounds and hollows, till men began to border the rounds by more straight lines, by members corresponding to that simpler shape of vault ribs or replaced by a simple intersection the coves in the angles.

The dividing arches of the church in Friedberg, of which Fig. 434 represents the older older ones found first in the transverse aisle, and Fig. 435 the slightly later ones of the western bay, makes apparent this last transition. A further example of the latter only consists of hollow members, then are shown by the dividing arches in the southern side aisle added to the collegiate church in Fritzlar about the end of the 14 th century (Fig. 436).

Proportion of the dividing arches to the rounds.

At the same time that this change in the form of the profile of the dividing arches was modified its proportion to the rounds of the pier. While according to the older system each round entirely bore a separate arch, we already see on the nave piers of the cathedral of Dijon the rounds standing beneath only the farthest projecting parts of the dividing arches. But men soon went farther and brought the shafts into separate relations to the different rounds of that profile, whereby also the diameter of the former must not exceed that of the latter, and then also carried the hollows down the pier, so that the nucleus of the latter entirely disappeared. Yet here at first is found a difference between pier and arch members, so that the rounds of the latter are larger than the shafts and vary from them by the added curves, so that they are at least generally more complex, and the capitals fulfil a real function. Such an example taken from the church of S. Katherine in Oppenheim is shown

by Fig. 437. But usually these differences entirely disappear, as shown by the pier reproduced in Fig. 438 from the church of S. Mary in Mühlhausen built about the middle of the 14 th century; the profile of the dividing arch there is the same as that of the pier, and the capitals are exceptionally necessary to the shafts standing beneath the cross and diagonal ribs, c carried around the entire pier until men succeeced in entirely omitting them, forming the pier only by vertically continuiong the members of the arch. Figs. 440 and 439 show plainly two s such piers, the first being from the Wiesen church in Soest of the second half of the 14 th century, and the last from S. Maclou in Rouen of the last time of the 14 th century. On the former the dividing and cross arches are alike and the cross ribs intersect at the angles between both. Conversely in S. Maclou the cross ribs partly increase with the diagonal ribs and the extreme members of the dividing arch and are extended in this form from the base of the pier.

Pier of the basal form of square set diagonally.

The ground form of all these members, both of the dividing arches as well as of the pier, is that of the square set diagonally, or yet restricted in the manner that only certain parts project beyond it. In it is met at the same time both earlier systems, for the cylindrical pier according to the size and projection of the shafts passes into this so far sometimes, t that it is entirely inscribed, and in the form of the fier divided in rectangular steps is this directly contained, when the separate sides of these steps are alike.

Very instructive in this respect is the treatment of the piers in the minster of Freiburg, where the stepped surfaces are entirely omitted, as shown in the upper half of Fig. 423, while conversely the members of the dividing arches are developed w with entire distinctness from the structural motive of the different concentric arches. The joints in the intrados of the d different arches therefore lead to retaining the steps, while the end joints of the piers could lie in the direction of the sides of the diagonal square.

The entire transformation thus consists in this, that first the direction of the diagonals in all details replaces that of the sides of the square, and further that the hollows ever become wider or more numerous, the rounds and shafts being dim-

diminished in the same proportion.

The development of the separate members from the diagonal square is indicated by aiding lines in Figs. 434 to 440. Although we cannot guarantee exact accuracy of this construction employed in the drawings, yet will they serve for for the approximate determination of the proportions of the details of the members to each other.

The undivided pier of the late time.

Besides the richer forms mentioned, to which the ground form of the single pier passed by combined combination with the shafts and by fusion with the formation of the membered pier, t there also extend through the periods of Gothic art numerous examples of retaining all this simplicity. It will even become more common about the end of the same, so that thereby almost a transition may seem prepared to the antique-like columns of the Renaissance, if not the latest Gothic forms of piers had not in principle opposed more strongly these columns, than the simple round piers of the early Gothic period. The course of the transformation of the early round pier into the late Gothic forms is the same, that we have just proved in the compound pier, and is expressed in the increasing harmony of the basal form of the prier with that of the dividing arch. But this harmony will be obtained conversely as in the compound pier, for while the latter vertical continuation of the profile of the arch forms the plan of the pier, the dividing arch is here formed according to the plan of the pier, and thus in both the c capital is superfluous.

Thus the dividing arch first retains a form differing from that of the pier and more or less richly membered, only its p projection becomes less and accordingly the sections of the v vault ribs are more compressed, so that the entire mass of the arch members finds room on the moderately projecting abacus of the capital (Fig. 441). There the pier can have a round or polygonal form. But the hollows of the profile of the arch still cut into the basal form of the pier. To avoid this loss of size, the arrangement is sometimes found so modified, that the plan of the pier continues above the capital and partly combines with the members. Then to avoid the projection of certain members beyond the continued nucleus of the pier, the nucleus is either above beyond the pier, so that it circulscribes the

springing of the arches is shown by a b c d in Fig. 441, or t the mass of the springing is contracted so that the plan of the pier can be inscribed withon it, as shown in the right half of Fig. 441.

In the first case the capital still fulfils an essential function, but in the latter it serves a more ornamental purpose, at most still indicating the beginning of the arches and therefore is finally omitted. Between the two arrangements lie those, according to which either the nucleus assumes a basal form differing from that of the pier with the same magnitude, and hence the capital must effect the transition from the round pier to the octagonal nucleus, or where the lowest member of the section of the dividing arch projects beyond the pier and the same condition appears with reference to the vault ribs, then the pier without a capital has four corbels, on which rest the projecting members mentioned, while the rest of the members of t the dividing arches grow out of the pier. (Figs. 442, 442a).

Also sometimes these corbels are arranged only for the vault ribs, while the members of the dividing arches are inscribed within the plan of the pier, thus entirely growing out of it, as indicated in the right half of Fig. 442. Likewise can be arranged shafts instead of the corbels, indeed either four or e even but two beneath the springings of the arches. Then may t piers and shafts be without or with capitals, or merely the shafts may heve them.

Polygonal piers.

Instead of the round plans of piers in Fig. 442 may also be introduced any polygon. The polygonal pier is found in the economically built churches of the mendicant orders already from the beginning of the 4 th century onward, as in the Dominicen church at Erfurt in the way, that the octagonal ground form of the pier continues in the dividing arch, whose springing is indicated by a slightly projecting capital. There separate corbels are arranged for the springings of the ribs, which either project above the edge of the capital as shown in plan in Fig. 444 and in elevation in Fig. 444a, or they start directly from the mass of the capital. Thus the moulding of the abacus can extend around the projection of the corbels, or the latter receives the finer treatment, or finally the projection may assume a freer form. A most happy form of the last kind is shown

by the little church of the village of Gottesbüren in Hesse, built about the end of the 14 th or the beginning of the 15 th centuries, of which a perspective view is given in Fig. 445.

In consequence of the slight elevation of the vault of the middle aisle amounting to a few feet above those of the side aisles, the differently shaped projections here bear short shafts, on whose capitals rest the cross and diagonal ribs, while for the side arches are arranged separate corbels projecting from the edge of the capital. With the same ground lines of t the vaults of the three aisles, the springings of the ribs rest directly on the corbels projecting from the capital, the side arches on the projection of the abacus.

The exaggeration of the thoughtful arrangement mentioned is shown by the capital from the princes' hall of the city hall in Breslau, where these corbels in small size project from all eight sides of the edge of the capital, arrarently being there only to bear the extreme members of the different vault ribs, that might well have found room on the edge of the capital itself.

The use of these corbellings above or in connection with the capitals is however nowise a peculiarity of the middle and late periods, but is adready found in principle in the works of the transition style, as in the aisle of the church of S. Sebald in Nuremburg and in many early Gothic works in France and England, only according to the arrangement of the raised middle aisle, so that these corbels bear the shafts that receive the ribs of the middle aisle. (An extremely beautiful example of a corbelling from the capital of the church in Semur in Burgundy is found in the Dictionary of Viollet-le-Duc, II, p. 514). The peculiarity of the later treatmentthus lies only in the greater hardness or economy of the treatment, thereby making itself particularly instructive. On the very slender round piers of the hall church of S. Croix at Liege all ribs are set on corbels. There for equalizing the heights of the ridges the corbels for the arches of the middle aisle of wide span are set lower than the others.

Also the older arrangement occurring in the cathedral of Paris, whereby the rounds belonging to the vaults of the middle aisle rest on the margin of the capital of the pier beneath the diagonal arch, are found in reduced size in the middle and

later periods. An example of this kind from the church at Immenhausen built about the beginning of the 15 th century is shown by the right half of Fig. 443 in plan. The octagonal pier continues in the dividing arch,and the springing of the ribs and the dividing arch rests on the edge of the capital. The f further reduction indicating the last period then consists in this, that the useless capital for the dividing arch is omitted and the springings of the arches either rest on corbels or grow out of the sides of the octagon toward the aisles. But conversely would easily result a function for the capital, whose omission produces the effect of a certain dryness, if the profile of the dividing arch has a form varying from that of the plan of the pier, as given in the left half of Fig. 443, and further in the left lower quarter of Fig. 444.

The polygonal ground form of the pier is sometimes modified in the last period by a concave form of the sides, yet so that the edges of the pier formed by the intersection of these segmental arcs always remain rectangular. Here is manifestly an endeavor for varied effect of shadow, that has caused this use of the nagain repewed polygonal plan. In the cathedral of Erfurt according to the same system the octagonal pier is carried into a richer system, particularly so that the angles are formed by rounds and the sides of hollows, that are separated from the former by fillets. However such a form is entirely different from the compound pier mentioned above, so far as any relation between the members of the pier and the different arches fails. It is far more nearly allied to those with the penetrations mentioned at the springings of the vault (Fig. 291), and varies from that only in the members of the pier including the capital.

Form of shafts.

Ground form of shafts.

Shafts with polygonal plan are rare, examples with octagonal shafts may be mentioned in the cathedral of Chartres and the side aisle of the collegiate church in Fritzlar; in the church at Wolfhagen near Cassel, which belongs to the early Gothic school of Westphalia, are found on each of the heavy round piers four shafts of square section. Otherwise round shafts p prevail, whose cross sections represent a larger or smaller portion of a circle. But from the 14 th century onward is found

the round plan sometimes transferred by a front projection into the sharp or pear shaped ogee shaft.

The origin of this not very fortunate form must be sought in this, that men sought to show the direction of the upper arch already in the form of the shaft itself. But if in Fig. 446 the lines a b etc. give the direction of the ribs, they determine at the same time that of the projection. The latter occurs in various relations to the bases and capitals.

In the simplest cases the base remains round and the projection rests on its upper member, that it intersects according to the shape of the base moulding, and then extends down to t the projection beneath, or the base moulding encloses the projection as indicated at g h g in Fig. 446. In the same way the projection either runs under the lowest member, stops at the astragal of the capital or intersects at and joins the greater projection of the mass of the capital or the foliage, or it is enclosed by the astragal, or finally by the entire mass of the capital.

Groups of shafts.

As already stated, in the simplest cases a shaft bears all vault ribs, as conversely in the richest design as when for e each rib is arranged a separate shaft. Such a group of shafts then forms a part of a compound pier, whose entirety originates by the combination of the required number of shafts. But sometimes are found in the works of the middle ages very peculiar forms of such groups of shafts. A happy example of this kind is shown by the castle chapel in Marburg represented in plan in Fig. 447. Here actual shafts are only arranged for the diagonal ribs, which are connected together by a hollow. The latter is then continued above the capital of the shaft in the cross arch, while the outer members of the latter, the members a b and c d grow out of the side surfaces of the diagonal ribs.

Rounds above the capital of the pier.

The rounds are as already mentioned if they are connected w with a pier, either if set on the ground or in aisles of unequal heights being placed on the projection of the pier capital under the dividing archor corbelled out over the latter. Placing them on the pier capital is found in certain French works of the early time, as in Notre Dame in Chalons, S. Remy of Rheims in the modified way, that on the capital of a larger round

standing on the ground, stand three smaller ones, when the capital is either at the height of the pier or above it. The last arrangement is found in Chalons. The position on the capital of the pier is found in an especially happy way in Notre Dame in Dijon, where the round stands without bonding with the upper wall, and the members of the dividing arch extend behind the round bearing the diagonal rib, so that it again becomes visible between the latter and that supporting the cross rib. We have represented the plan of this form in Fig. 286, which Fig. 448 shows in elevation.

Rounds corbelled out from the fier.

Frequently only a part of the shaft extends down on the pier, while another is corbelled out higher on it. This already occurs on Romanesque and early Gothic works, that the shafts for the ribs first begin higher, and among other things there may have led to this a later decision for projecting groin arches. The cathedral at Riga was at first begun as a hall church at the beginning of the 13 th century and shows this solution in the stepped and entirely Romanesque piers of the aisle and the wall (Fig. 450). Likewise also the round piers in many Westphaliay churches, like the cathedral at Minden, the church at Volkmarsen, etc., have four corbelled shafts for the ribs, while the four shafts for the cross and dividing arches start next the ground, so that the arrangement is entirely regular.

For round piers with four projections the shaft next the middle aisle is sometimes placed higher, as in the church at Haina, where it begins about 12 ft. above the ground. In the church of S. Christopher at Mayence, also dating from the 13 th century, the shafts for the clearstory even first begin above the capital. Io the market church at Hanover (15 th century) conversely the shafts under the dividing arches are corbelled out of the mass of the cylindrical pier, and thuse next the aisle start from the ground.

To extend the view under the free space may have first led to this abrupt corbelling, that is very justifiable statically. Thus in the predominance of the thrust of the middle aisle it would naturally result to save partly the shafts of the middle aisle no longer stressed, but conversely would be quite proper to extend down the most strongle stressed shafts in the side aisle and set then on a widened foundation.

Shafts on the walls.

Shafts are attached to the walls as well as to the piers, but some special arrangements occur there. For sometimes the shafts only start from the moulding extending under the window sills, or it is found in the arrangement of three or five rounds that this plan is only employed on the outside ones, while the middle ones axtend down to the ground.

Another arrangement already peculiar to the transition style is likewise found in the before mentioned Westphalian churches in which in particular a segment of a pier is first placed at the surface of the wall, and the shafts are corbelled from this In Volkmarsen the execution of this form is very simple as shown by Fig. 449, as this was already brought in by the spanning of the side aisles with vaults without ribs. On the contrary in Minden is it executed with the greatest richness. Above a figure standing on a corbel a semicircular canopy forms the basis of the corbelling, that by a bold hollow covered by leaves obtains a larger surface and forms the cornice of the canopy, on which rests a short portion of a pier bonded with the wall, to which are attached five rounds, namely a larger one for the cross rib and four smaller ones, two of which bear the side arch and two the diagonal rib. The smaller rounds stand on the projecting cornice edge of the lower corbelling, but for the larger is arranged a corbel projecting from this edge. All rounds have capitals, whose upper moulding extends around the c corbelled nucleus of the pier.

Such treatments are of use, since they leave the lower part of the wall flat and those seats in churches and benches or o other furniture in secular buildings may be set close against the wall without being restricted by the shafts extending downward, thereby producing a rich and massive effect; they further strengthen the abutment since they lessen the spans of ribs.

Ratio of size between pier ant springing of arch.

As for what relates to the ratio of the supported to the supporting part, the plan of the ribs to that of the shafts, that of the entire springing of the arches to the pier, the general rule is valid, that the area of the supported part at laeast equals that of the support, but is mostly larger than the latter. The basis of this almost regularly occurring appearance is to be sought in this, that the plan of the springing of a

vault for architectural and practical reasons only allows a reduction within certain limits, and that on the contrary the plan of the pier when no thrust is in question can be very strongly reduced. If only the resistance of the material to compression is considered, then as a rule the dimensions of the pier can be made very slender.

A prismatic pier of sandstone or limestone (specific gravity = 2.5) can be built 80 m high before producing a compression of 20 kil per q cm at bottom. If 40 kil per q cm be allowed t the pier might even be 160 m high. If the beds were sufficiently hard, the crushing of the material need not be feared with a much greater height)..

Taking a pier that must support a vaulted area of 50 q m (about 7 × 7 m) with a weight of 25,000 kil, with an allowed compression of 20 kil per q cm, $\frac{25000}{20}$ = 1250 q cm area, or about 35 × 35 cm would be required. But to reduce the springing of a vault od 7 m span to this little area would scarcely be considered.

Usually the proper area of the springing of arches and of pier are fixed separately, so that one is often led to have the arches project as far as the projection of the capital permits. Thereby is obtained a smaller span of the arches, a less compression of the members and usually an easier constructio

If the springing of the arch and the plan of the pier are to be exactly equal in area, then usually a greater diameter is given to the springing of the arch, since this is weakened by the projecting angles of the members, but the pier has an entire outline. It is evident that the projection of the mass diminishes when the plan of the pier is simpler than that of the springing of the vault, and conversely that the projection will be less, the more nearly similar the pier and springing become, until finally with complete harmony of both all projections d disappears. The later time of the middle ages has particularly sought a direct transition from pier to springing of the vault without intermediate capital (Figs. 288, 291).

A certain justification cannot be refused to endeavors like these, since after combining the forms of the vault in the springing of the arches the material suffers the same compression as in the part of the pier beneath. If the pier and springing can be made of the same stone with equally careful joints, it

is admissible to give them equal areas in plan. It has just b been stated that other reasons again oppose this equality.

With smaller dimensions as may occur in secular buildings, halls etc., the reduction in size of piers has limits set by conditions of execution and of resistance to accidental injuries; since then in such cases the otherwise small stresses can afford no such advantage opposed to an increase in the dimensions of the springing of the arch, but on the contrary it may produce a heavy effect, and then its projection beyond the face of the pier must be omitted. An example of this kind is offered by one of the halls of the monastery of Haina, the so-called bitter chamber, whose springings of the arches formed in accordance with the principle of Fig. 287 scarcely project beyond the line of the cylindrical pier supporting them. Further much depends here on the nature of the material. Thus on the extremely slender granite piers belonging to the so-called Brief chapel in the church of S. Maria at Lübeck, as well as that found in the refectory of the castle of Marienberg, the springings of the ribs project but slightly beyond the face of the pier, trusting the excellent quality of the bricks composing it, while for the equally slender piers of the refectory of S. Martin des Champs in Paris, the diameter of the springing of the ribs is apparently thrice the upper diameter of the column.

The bold piers at Lübeck and Marienburg seem comparatively even bolder in comparison to the yet bolder springings of the vaults, which in consequence of the recesses have even a smaller area than the piers, in spite of the springings being of brick and the piers of the much harder granite. One might conclude from this that the piers should have been far more slender; but it is not so. --- With very slender columns there is not only the resistance to compression, but the danger of bending or breaking is to be considered. Further in very small piers is increased the possibility of splitting in consequence of hidden defects in the material, entirely aside from the fact that the pier is more exposed than the springing of the vault to accidental blows or injuries.

However just at the springing in brick is required a certain greater projection for construction and artistic effect, although in a given case to the unusual and aspiring effect of the vaulting cannot be denied an almost fascinating charm.

2. The Capitals.

Form of capital with round shaft and square abacus.

General form of the capital.

The capital usually has to fulfil two purposes, it first has to create by its projection a greater area to receive the supported members, and second to transfer the cross section of the support into another suitable form of plan. With especial frequency it concerns the change from a round shaft to a square abacus; both for beams as also for simple arched members d does the square abacus offer a bearing area suited to the purpose, and further it gives the most natural form of a cut stone.

In Romanesque art the fulfilment of both requirements was combined in one part, when the single body of the capital produced projection as well as transition, where yet the projection was by a boldly moulded slab, frequently enlarged by the addition of a separate cut stone. Figs. 451 to 453 represent three ornamental additions.

The Gothic takes care to separate the two functions, and like the Corinthian capital it effects the projection by the bell of the capital, but the transition is by the circular form of the abacus laid thereon as shown by Fig. 454 in contrast to Fig. 453. The abacus may project more or less beyond or be inscribed within it. (See plans in Figs. 454a to 454c).

Supporting leaves at the angles.

The overhanging corners of the abacus (Figs. 454a, b) were supported by a corner leaf, a bunch of leaves or a supporting body formed in another way. Even if the angles do not project, as in the plan of Fig. 454c and on the capital from Volkmarsen represented in Figs. 455 to 455b on Plate 37, still is recommended a strengthening of the angles by supporting leaves; for as shown by the diagonal section in Fig. 455b, there is less of the bell beneath it than at the side of the slab, and it therefore is next to strengthen the edge of the capital beneath the capital by a support, so that the line a b c becomes the line a d c.

Fig. 456 exhibits the elevation of such a simple form of capital, that has angle supports of full square cross section at top, flattened to the shaft below and finally passing into it. Accordingly the form of this support approximates the form of the fleshy leaf or stem cut off at top, Fig. 457 representing

its elevation at a larger scale. More animated than these cut off "dead"members are the leaves developed entirely to the point, that are represented in simplest form in Fig. 458.

Since the point e in the plan of Fig. 458a denotes the extreme corner of the cut block, then may the angle leaf project so far beyond the edge of the bell as the block permits, so that its end as given by the right half of the plan and elevation shows, with leaves cut off is moved back to h i, or with pointed leaves nearly to e. Further to separate these leaf supports more sharply from the surface of the nucleus of the capital remaining between them, they are supdivided below and indeed in the simplest cases by two hollows g sunk in the right half of Fig. 457, which also flatten below and lie against the nucleus of the capital, hence assuming the form here given in plan in Fig. 457a or by a richer profiling, visible in the left half of the same Fig. More animated is this treatment, even if the lower also cracks, and both its parts separate in the mass as they near the nucleus as in Fig. 457 at x.

The form of this support as here represented, for example as found on the corbels of the church at Haina, is not the oldest, but on the contrary is to be regarded as one of the earlier and most richly derived, but we hold it advisable for its clarity and simplicity, made easy by the geometrical treatment in such a high degree, to allow it to precede the richer forms and to regard it as the root of the latter.

Two rows of leaves above each other. Development of the angle leaves.

For a greater height of the capital the need of architectural`animation and the utilization of the mass of the cut stone leads to the form similar to the leaf-like supports in half the height or somewhat higher, and to its repetition, so that the leaves curl forward free from the nucleus, yet the angles indicate a diagonal square within the square of the cut block. Then the upper leaves spring from between two lower ones, so that both rows have the same position as the acanthus leaves on the Corinthian capital. Accordingly there results the form represented in Figs. 459 and 459.. These are more graceful when the plant character of these supports more strongly appears, and also if instead of teeth the ends are formed by points of leaves coiled upward or downward. Such very simple capitals are

formed on the round piers of the high choir of the collegiate church at Mantes. Fig. 400. (Note). It is generally first the varied mode of treatment of these supports and their ends, sometimes carried to the greatest richness, which characterizes the various capitals of this kind. We can here indicate this endless diversity in only a few ways. That triangle e a e projecting over the edge of the bell in Fig. 455a gives the mass of these endings, from which develop knobs, buds or leaf forms, that lie before the edge of the bell, transform this into the square ground form, and produce the same effect as the volutes of the Corinthian capital, in a very happy way as we think. F Figs. 461 to 461d, 462 to 466, 469, 473 to 480, show different examples of gradual progressive development of these forms, w whice includes a transformation like that of the development of the bud into the leaf.

Figs 461 and 461b show the buds still entirely closed in the simplest form like knobs. Characteristic for this simple form is the almost typical arrangement of two knobs into whiah the support divides. From this develops the more unrolled leaf divided below in a form like Fig. 464, which reappears with special frequency in Germany and France, and by its easy recognition produces a peculiarly tasteful effect. Fig. 463 then shows a simple leaf closed as in the bud, while Figs. 465, 469, 469a and 480 exhibit recher but still closed forms of buds. Fig. 4 462 shows a fully developed leaf, Fig. 466 has a formal bunch of leaves, and Fig. 474 is a later and more conventional shape. Simpler forms are the leafy endings replaced by heads, as in the choir of the cathedral at Wetzlar (Fig. 471), or the entire support has become a great animal's head, of which Fig. 470 is an example from the same place, and Fig. 472 represents a second from the cathedral of Besancon.

Note. A capital from the same row of piers is found in Viollet-le-Duc's Dictionary, II, p. 512, in which the ends have two leaves above, with two curved downward.

With the existence of a second row of leaves the upper one can be of the same form, but the lower row usually has a different shape, and consists only of more or less strongly conventionalized leaves added to the nucleus of the capital. Examples of these are given in Figs. 461, 462, 480. It is essential to the effect if the entire capital, that all parts attached to

the capital, the supports at the angles as well as the leaves in the lower row, should curve outward in a line similar to t the profile of the bell and thus enhance the effect thereof. Therefore the line of the profile visible in the Fig. above is particularly characteristic.

With a stronger projection of the capital,the middle of the edge of the bell may also be strengthened by supports in the same manner as the angles of the abacus. In this wise are then formed the supports of the capitals in the aisle of the cathedral of Rouen (Fig. 463).

The body of the support, that we have previously seen animated by a simple subdivision, is sometimes ornamented by underlaid leaves, and these leaves are either simple as in Fig. 463 or are arranged in greater number,and in the last case lie in the most varied arrangements from the middle lines at both supports toward both sides. A simple example recalling Romanesque ornament of this kind is shown by Fig. 465 from the rood screen of the church in Friedberg.

Transition from the bell to the abacus.

We have placed the lower square of the abacus within the circle of the edge of the bell represented in Fig. 456.. But thereby becomes necessarn, particularly with a greater diameter of the column, a larger projection of the margin of the bell beyond the sides of the abacus and wide projections of the members of the latter, if it is not to remain behind the edge of the bell, and further the edge of the bell itself must already have a considerable projection, if the abacus is generally to project still from the line of the column, and so finally these strong projections and ressessions also require a height for the entire capital, which must lead to a heavy disproportion. But this tendency will be avoided when the lower square of the abacus extends its corners beyond the edge of the bell, while the latter still retains the propections of the middle of its sides of the abacus. But by a similar arrangement will the need of the angle supports be increased, that now those p projecting angles of the slab lie upon, so that the edge of the bell either stops against the sides of the abacus or the endings of the supports, or at the latter.

The oldest form of this kind is that, where the projecting angles retain their horizontal undersides, that remain visible

between the supports and the edge of the bell, as shown in Figs. 462 and 461, the first from the collegiate churbh in Mantes and the latter from a portal located on the eastern side of the north transept of the cathedral in Mayence. In the last Fig. the ground planmakes clear the proportion by which the triangle a b c represents that horizontal surface over the support. On the first Fig. we call attention to the edge of the bell placed on four arches, an arrangement that is also found in a similar way in the choir of the church at Gelnhausen and produces an extrebety animated effect.

But men soon sought to avoid these horizontal uwder surfaces and thus passed to the forms represented in Figs. 466 and 464. Fig. 466 represents a second capital from the Friedberg rood screen, and the body of the abacus rests directly on the bunch of leaves that forms the end of the support of a triangle a b c that has a corresponding size, while the edge of the bell cuts into the thickness of these leaves, and there also rises from it a wash, that rests against the side of the abacus. Another shape results when the abacus rests with a cove on the top of the bell, but this cove follows down on the angles above the edge of the bell and intersects the wash forming the back of the support (Fig. 464). A more complex but entirely happy solution is shown by a capital from the sedilia in S. Blasien in Mühlhausen (Fig. 467), which in a way joins together the peculiarities of both forms last mentioned. Here a wash rises from the edge of the bell that joins on the lower edge of the abacus but goes down over the edge of the bell around the vertical continuation of the body of the slab resting on the leaves of the capital, at which the edge of the bell also stops. The projection of the corners of the abacus beyond the edge of the bell is further reduced or entirely prevented by cutting off the angmes, so that now the ground form of the abacus is an octagon with four large and four small sides. An example of the last kind, which at the same time forms the transition to the capital with polygonal abacus is shown by Fig. 46

Form of the bell.

In the Figs. so far represented are given the most diverse forms of the three parts of the capital, namely the abacus, b bell and astragal. The profile of the bell, formed as an extension of the shaft of the column by a cavetto, yet in a way that

the latter still extends above the astragal, only passing into the cavetto at about midheight of the bell or higher, which is nearly typical and varies only in regard to the projection of the edge of the bell and the height at which this cavetto begins. Seldom fails the continuation of the shaft above the astragal, as in one from the hall of the former Dominican monastery in Erfurt, and the bell is then shaped in a freer curve. The thickness of the foliage projecting far from the ground of the bell sometimes extends at right angles to it on the older works. But already in the first half of the 13 th century the leaves are also undercut, so that their edges form an acute angle with the nucleus. Such an example from the nave of the minster at Strasburg is shown by Fig. 514. But sometimes the nucleus of the capital assumes a section line swelled to near the main profile of the foliage as shown in Fig. 467, so that thereby the projection of the leaves is reduced. This form is shown by the capital from the church at Frankenberg dating from the second half of the 14 th century, and it made the execution much easier, but also causes a far weaker effect of shadow. The edge of the bell is formed by a fillet in the simplest way, as may be seen in Fig. 510a at b. This fillet sometimes receives a wash above or is rounded off, either only above or also below; in the same way is also broken the lower edge by a chamfer as in Fig. 461 or by a cove. More rarely does the edge of the bell assume a form differing from the circle. A very peculiar example of this kind is shown by Fig. 468 from the vestibule of the cathedral at Dijon, where the ground form of the edge of the bell still strikingly recalls the Corinthian capital. Another example is given in Fig. 462a.

Height of the members of the abacus.

Of special importance for the good effect of the entire capital is a certain height of the abacus, at least for the previously described and mort structural forms of capital, in which the abacus generally assumes a predominant individuality. This height is in a certain proportion to the projection of the capital or rather to the size of its form of plan. It cannot indeed be formulated since in general Gothic architecture rejects all timid restraint by proportions. Already the endless diversity of its forms would make any such regulation impossible. Usually the ratio of the height of the abacus to the side of

the square lies between 1/4 and 1/2, being usually high in the early time and lower in the late time. The profile of the abacus almost always shows a vertical side, which becomes an almost essential part, if the angles of the abacus project beyond the edge of the bell. The upper edge of it is surrounded by a moulding, whose simplest form is a coved enlargement (Fig. 481). Instead of the upper fillet this cove is sometimes terminated by a round above, and then is also undercut as in Fig. 482, or a round is formed with fillet above as in Fig. 483. The moulding is richer when the cove is separated below by a recession or a little round from the vertical side as in Figs. 484 and 485. A particularly effective moulding is that shown in Figs. 486 and 487 (also see Figs. 461, 465 and 469). One projecting farther and strongly undercut in form is then shown by Figs. 468 and 469 (also 480), and Fig. 468 is one more antique. That lower side of the abacus denotes as a rule the extreme projection of the arch or rib resting on the capital, especially if the upper edge has a strong projection with small height as in Figs. 488 and 489, while with a steeper profile as in Figs. 481 to 485 can also the projection of the edge at least partly serve the rib as a support.

If the uppermost member of this edge is a fillet, then it e ends either in a rectangular edge or a chamfer as in Fig. 486. This chamfer is replaced by rounding as in Fig. 489 or even by an ogee, two examples of which are given in Figs. 490 and 491, the first from the lower blind arch in the cathedral of Chalons, the latter being from the corresponding part of the cathedral of Rouen. Further the chamfer can be formed as a wash, that r rises from the extreme edge to the deepest part between the intersecting members of the arches. Especially in the open air this arrangement has a certain practical utility, so far as it removes rainwater from the joint; it starts from the member of the arch and must then be left on the capital, so that its form is that shown in the perspective view of Fig. 492.

Form of the astragal.

The astragal is most simply formed as a round as in Figs. 493 and 494, whose profile however is seldom an actual circular arc, but generally shows a free movement as in Figs. 495 and 496. But more decided is the effect if it has a lenticular shape (Fig.

497), which either consists of two symmetrical or unsymmetrical curves, the lower having a flat recurvature and in undercutting (Fig. 498), the latter being sometimes more sharply expressed by an added fillet as in Fig. 499. The form is richer if a hollow is cut in the lower half as in Figs. 500 and 501. The last shape then usually suffers a modification by the upper s surface formed as a curve being changed to a wash (Fig. 501a).

On capitals of very small projection is sometimes found a t transformation of the profiles described in the manner, that these increase in height in a certain way in the same proportion as they lose in projection, so that the members of the abacus are only formed out of a vertical surface. Such an example from the chapter hall of the monastery of Haina is shown by Fig. 536.

Capitals with polygonal and round abacuses.

Octagonal abacus.

We have already described above an abacus of square plan with angles cut off. By a corresponding increase of this cutting the square plan passes to the regular octagon. The advantages of the polygonal slab may be comprised in this, that the total m mass of the arch mouldings resting on the capital as a rule differs much from the square and therefore approaches a polygon, it being consequently that the angles of the square remain without loading, and a form of capital with an ugly projection diagonally would be required. The general acceptance of the polygon during all periods of Gothic art, the first of the octagonal form is mainly connected with the endeavor to express the vertical direction in an enhanced manner, and to assign to the horizontal an always subordinate place. The effect of the vertical direction, which at least in the interior is first of all expressed in the system of the pier and rounds and in the connection of the last with the lines of the arch, but at least when seen diagonally is substantially injured by the great projection of the rectangular angles. Men then already in the transition style had believed that they found an inconvenience in this, and usually placed on the square capital the lowest block of the arch in square form, but in the latter formed the transition from the right angle to the arch mouldings in a far richer way, than could be directly placing it on the capital.

To this is added, that the grounds deduced above from the o original form of the cut block for the square shape of the capital fail, as soon as it concerns the forming the capital for a group of shafts or for a compound pier. But also structural advantages are connected with the adoption of the polygonal form of capital. First this form more easily permits a departure from the shape regular on all sides that the square, but then the arrangement of the washes represented in Fig. 492 occupies much less height than for the square.

Thus now the octagon generally comes nearest to the springing of the vault consisting of several arches and ribs, hence for a single pier or for all rounds supporting several ribs it is the most suitable form of capital, so that the hexagonal capital set diagonally frequently corresponds better to the plan of a certain rib, and the predominant relative height of the profile of the rib may lead to making the angle placed in the direction of the rib more acute, nearly equal to a right angle and so pass over the regular polygon. An example of such a hexagonal capital is seen in Fig. 511.

Likewise in certain cases the peculiarity of the plan of the arch leads to the change of the regular into an irregular octagon. Such cases occur first in the pier arcades of polygonal choirs furnished with a choir aisle (Fig. 425), but still may also be caused in nave piers by special arrangements like those of the pier from Notre Dame in Dijon shown in elevation in Fig. 448 and in plan in Fig. 286. But yet more commonly is found to be caused such a departure from the regular form, because that on the capital of the round bearing the diagonal rib must set also the side rib or a round supporting it, so that then the abacus demands an enlargement of the surface enclosed by the regular polygon.

Since in all these cases the plan of the springing of the arch dominates that of the abacus, thus on certain shafts in the south side aisle od the Minorites' church in Cologne, the placing of cross arch, two diagonal arches and two side ribs on one capital led to a star shaped blan of the abacus.

Elevation of the capital with polygonal abacus.

The form of the elevation occurs with the just mentioned form of plan of the abacus in the same way as for the square. The body of the abacus borderes by the vertical side surfaces

are set on edge of the bell or projects over it, indeed only by the angles or so that the circle of the bell is inscribed within the octagon. Sometimes then the area of the margin of the bell projects by a chamfer formed on the lower edge of the abacus (Fig. 480). But in a certain way is modified the proportions of the leafy support. If as on square capitals this support of the projection of the corners, under each of the eight angles is one, therefore being eight on the entire capital, or sixteen if two rows of them are formed. Such an example is shown by Fig. 448. - similar form is sometimes already found on sqaare capitals with cut off corners, as on certain rounds of the nave piers of the collegiate church in Mantes. This supporting of the angles of capitals is particularly necessary where this entirely or partially projects over the edge of the bell, as for the irregular form in Fig. 448. But where the last is not the case; where the capitals rest on the edge of the bell, this support of the angle necessarily disappears, and supports occur exclusively in relation to the edge of the bell, and in a certain sense form a strengthening of it in a way, similar to a cornice slab supported by corbels, and accordingly may also have a different number and position, when they are placed beneath the middles of the octagonal sides, are arranged in f fours on the bell, and either rise from it in the direction of the side as in Fig. 480, or in the diagonal of the square.

On the capitals of the rounds and columns of the 14 th and 15 th centuries, the transition from the round to the polygonal form of the top is made by a rounding of the surfaces and cutting off the angles from above downward. The profile of the capital then corresponds to the one developed from the round, i.e., a projection of the edge of the bell becomes superfluous, and the supports of the angles are omitted, or rather are replaced by the gradually formed angles, to which they stand in a similar relation as the ribs to the groins in the vault. Thus there also lies in the apearance of these angles the means for obtaining any irregular form of polygon for the top. On capitals with foliage the angles will be entirely or partly concealed by the foliage, and they appear only at the edge. The entire condition will be clearly illustrated by comparison of Figs. 502 and 503, the first of these representing a capital without leaves formed in the older manner from the cathedral of Dijon,

the latter being one shaped as stated above.

Circular abacus.

Allied to the polygonal is the round form of abacus, that is the rule on nave piers in England, occurs commonly on the earliest works in Westphalia and Hesse in Germany, and here first passed into the polygonal in the 14 th century. The advantages of it over the square are substantially the same as for the r regular polygon. On the contrary it lacks flexibility, which is peculiar to the latter by the transition to the irregular polygon.

Since the round capital remains in the form of the plan of the shaft or column, it merely has only to form a projection. However the arrangement still remains the same in at least the older examples, that was developed from the functions of the square and polygonal capitals. The bell is terminated by a fillet on which lies the round abacus, and even the supports retain their places. Fig. 510 shows such a pier capital from the middle aisle of the church in Wetter in perspective, and 510a is the corresponding profile. Fig. 505 then extibits the capital of a round of the church at Haina, in which the original shape of the support is retained in more decided form, and Fig. 506 is a capital from a window pier of the church of S. Elisabeth in Marburg. But it cannot be denied, that this arrangement becomes purely conventional, thet strictly taken the abacus is merely the moulded band of the bell, the leaves form less a support than an ornament of the bell, and that it therefore was only to bring a changed proportion into expression, like that on the capital of the church in Volksmarsen (Fig. 507), but even more decidedly in the capitals of the rounds on the cloister at Wimpfen im Thale (Figs.508 and 509). Retaining that older mode of treatment accordingly merely finds its full justification by the unsurpassed clarity of its effect.

Capitals of polygonal piers.

The capitals of square piers have in common with the capitals of round piers, that no transition to one form occurs in the other. Accordingly the projecting edge of the bell is omitted, the supports under their angles become necessary only by their greater projection and are repeated as a rule on the greater breadth of the capital or again at the sides.

Very beautiful examples of this kind are found in the choir

of the cathedral at Wetzlar, two examples of which we bring in Figs. 469 and 470. The arrangement of Fig. 470 is more consistent, as the greater projection of the angle here has also found a bolder support. On Fig. 469 is the extremely thoughtful arrangement of the leaves placed under and between the supports, the upper ones leaning toward the support and thereby producing an extremely living effect, as well as the beautiful a and powerful treatment of the foliage is to be considered, of which our Fig. indeed can only give but an imperfect conception Fig. 469a then shows the ending of another support of the same capital.

The capitals of polygonal piers either continue in the basal form of the piers, or change into the square. In the first case their development in elevation becomes that of the round or octagonal, but in the latter corresponds to that of the capital of the square column, and the support where attached to the nucleus of the pier has a profile corresponding to the angle of the pier. It is further to be noted, that the transition of t the square is easier from the diagonally placed octagon, since then the corners of the abacus come to stand on those of the edge of the bell, but are best when the octagon of the edge of the bell is inscribed in the square of the abacus. However the border of the capital could also take the round form, and then in the body of the bell itself is to be made a transition from the octagon to the circle. This occurs thereby with angles over the astragal yet corresponding to the angles of the polygon and connected by the sides of the polygon ever become more flattened, and are entirely lost under the capital, and that in the same the connecting surfaces, originally plane, gradually increase and finally pass into arches corresponding to the rounded octagon.

Foliage capitals of the middle and later time.

Branches of leaves.

The forms of foliage capitals of the middle and later periods are rooted in the different arrangements of the early Gothic. Thus we have already stated above how at first the closed leaves expand and they conceal the body of the support, which accordingly serves merely to allow the projection of the bunch of leaves before the body of the support, and particularly when this original function of support in the changes mentioned re-

recedes more to the form of the capital. Therefore it receives an ever more subordinate form, and soon is expressed only in the stems becoming visible beneath the bunch of leaves, while the connection of the leaves with the capital is made by the angular or oblique direction on the surface of the parts last worked, which already appear in Fig. 466. Therefore the entire form consists of bunches of leaves with stems attached to the nucleus of the capital in either oblique or angular direction, and in the last case may be concealed by the leaves themselves as in Fig. 526. Fig. 507 exhibits an example of the kind from the church in Volkmarsen. These bunches begin with two or three leaves and are generally so arranged that the middle leaf forms a wrapper or a bold projection from the others. Fig. 511 shows an example taken from the northern stairs of the rood screen of Mayence cathedral, where by a similar arrangement, by the contrast of the strongly projecting middle with the flat side leaves, the quiet and clear effect of the support finds a happy addition. These bunches of leaves are repeated either around the capital in one or two rows, or sometimess the entire ornament of the capital consists of three leaves expanding from t the adjacent stems, as on a capital in the choir of S. Blasius at Mühlhausen (Fig. 513). In the nave of the same church is also found the less happy arrangement, where the leaves have their points turned down and attached to the edge of the bell.

Just as on the older capitals that support the attached leaves forming the lower series (Fig. 480) are sometimes replaced by a lower row of supports projecting out free from the nucleus, there is also found the converse. Then is shown by an example in Fig. 514 taken from the nave of Strasburg cathedral, the supports are replaced by a repetition of that row of leaves. The strong and powerful line of the latter allows them to appear not unsuited to the changed purpose.

In Fig. 467 we took an early Gothic example in which two rows of entirely regular leaves are attached to the nucleus of the capital. But usually this vertical position of the leaves is replaced by a more flexible bending sidewise. They either all bend in the same direction or the points of each pair separate; either parallel or divergent in two rows. They either lie open or are partly concealed. But almost always their arrangement is characteristic, such that it impresses itself as a happy

melody and affords proof, that the stonecutter who executed it worked not merely for decorative effect, but that he actually invented the use of a modern impression, in brief the use of a motive therein. A very simple and graceful capital of this kind is shown in Fig. 512 from the southern stairs of the rood screen of Mayence.

Attached branch of leaves.

Already in the works of the transition style are sometimes found capitals, whose ornament consists of a branch with growing leaves, flowers and fruits twining around it in apparently naturalistic form. (Note). Likewise sometimes occur on the early Gothic and round capitals branches attached between the supports, whose leaves expand in an entirely unsymmetrical way; thus on the capitals of the vestibule of the foundation church in Fritzlar, dating from the first half of the 13 th century. In the so-called Jews' bath at Friedberg are then found square capitals, on which by the systematic arrangement of these branches with the leaves growing on them and partly bending around them are replaced the supports of the corners, or rather compose a formless mass entirely covered by these branches; Fig. 515 shows one of these capitals. But soon and already at the end of the 13 th century, men began to replace attached branches of leaves by smaller branches with few leaves applied to t the body of the capital. Thereby was a means given for obtaining greater variety, when the buds, flowers, berries and fruits growing on those branches were drawn into the circle of ornamentation. Meanwhile such examples are already found on early Gothic work, although occasional and in severer treatment, yet for example here the bunches of grapes are yet enclosed by the leaves with the flowers seldom expanded. In Fig. 516 we give an example of such branches of the middle of the 14 th century from the capitals of the portal of the south transept of S. M Maria's church in Mühlhausen, and in Fig. 517 is a similar one from a pier capital in the interior of the same. Besides this arrangement allied to the before mentioned branches of leaves, also sometimes the entire capital is surrounded by such a branch, that either stands obliquely or lies like a garland on it, so that the leaves grow of themselveu on all sides and are interwoven by flowers and fruits.

Note.

Note. A beautiful example of this kind from the cathedral of Karlsburg in Siebenbürgen is found in the Jahrbuch of the K.K. Centralcommission. Vol. III. p. 182.

Treatment of the foliage.

Such a pretext then requires also a free technical treatment and thus the thickness of the leaves is undercut in a direction forming a very sharp angle with their surfaces, whereby the acute angle at the corner is avoided by a chamfer or a rounding In the same manner are also undercut the fruits, flowers and stems, so that freed parts are already found on certain strongly Romanesque capitals at Gelnhausen.

If the forms described now advance in the path of a progressive imitation of nature, then also occur beside them other motives likewise derived from early Gothic works, whose different mode of treatment led to the opposed results, and even in late Gothic works supplanted those naturalistic forms, to replace them by sketched outlines of foliage. Thus are sometimes found obscured in the attached bunches of leaves the division of the separate leaves by a freer mode of treatment, so that the three leaves appear comprised in a single larger and compound one. Such an example was already shown in Fig. 468. But beside it are also found capitals, which indicate the previously considered treatment of such rich leaf forms, indeed already from the first half of the 13 th centurw, as in the eastern side of the cloister of the cathedral in Erfurt (Fig. 518) in an extremely delicate manner of treatment, almost like miniature. And later and still more graceful forms of the same kind as then shown by the capital (Fig. 520) taken from the lower blind arch in the interior of the cathedral of Chalons.

Where the distance of such leaves from the eye was greater, on account of recognition they must naturally be in larger lines, as shown by some of the upper capitals of rounds in the cathedral of Rheims (Fig. 519). But generally the size of the surface occupied by such a leaf requires an increased modeling, of sharper accenting of the outlines. Especially worthy of imitation in just this respect is the mode of treatment peculiar to certain forms of capitals of this kind from the second half of the 13 th century, an example of which we give in Fig. 520. The characteristic of these particularly consists in this, that by the arrangement and location of th

by the arrangement and location of the separate parts of the leaves are formed certain parts, and thus the clarity and quiet of the earlier capitals with supports are attained. Thus Fig. 520 repeats the geometrical principle of Fig. 480 in an entirely altered form. The supports are formed by the upper ends of the four principal leaves lying under the edge of the bell, w whose lower sides bend obliquely over the smaller intermediate leaves, covering the latter in a certain way, and in connection with them fomming a substitute for the projection of the lower row of leaves. Similar forms are then found on the capitals of the columns of the blind arches of Strasburg cathedral and in a more naturalistic way also in Freiburg. In the latter forms of capitals these thoughtful arrangements disappear, and from the 15 th century onward it was sought to animate these great surfaces of leaves by excessive movement of certain leaves, by increased bendings and swollen excrescences. Meanwhile are found yet in the last period beside this overloaded shape even more simply treated works distinguished by execution with a certain economy. We have given in Fig. 521 an example of the last kind which belongs to an alteration made in the church in Volksmarsen executed in the 14 th century.

As for what concerns the proper treatment of the foliage, we can only indicate this in merely a few great lines, since in general little has been done here in words and even in drawings made at small scale, and rich information can only be obtained by the study of the monuments. In the first Gothic works appeared the strongly conventionalized Romanesque leaf, but it soon disappeared. The Foliage of all periods of Gothic art finds its models in nature. Scarcely can a tree or a plant be mentioned, which was not drawn into the circle of ornamental forms. This diversity is sometimes so great in even the simplest and smaller works, that as Kreuser already stated, the endeavor to give all that lies on the earth its place in the church cannot be denied. But preferably are the maple, oak, ash and beech, white bryony, celandine, vine, ivy and hop, rose, aconite, turnip, clover and cabbage, have served as motives. The expression od motives is so far incorrect, since in the best periods an actual imitation of the natural vegetation was not intinded, but its forms were transformed by the style into the various orna-

ornamental forms.

Foliage of the earlier and middle periods.

In the early Gothic period the different leaves aid in producing the capital, they fulfil in a certain sense a structural purpose, and their removal would classify the body of the capital as a deformity. Accordingly it is the profile of the bell or the rounded ending of the support which prescribes the characteristic line of the leaf. The characteristics of the natural leaf must therefore be simplified according to these predominating simple curves and be reproduced in larger lines. Thus are found everywhere sharply accented contours, on which all little points and bends are omitted, broad surfaces either entirely without ribs or divided by merely angles and deeply cut channels, the modeling is kept simple, so that in the leaf itself are formed broad and soft tones of shade. But where the profile line of the leaf makes a short bend, this effect is sometimes strengthened by rounded swellings, whose bold shadows contrast with those softer ones, and so aid the entirety to a more vivid effect. But in the measure that the foliage becomes an ornament attached to the bell, men strove to multiply these effects, also to bring the swellings where they were indicated by the principal lines of the leaf, until also the latter gave the form a more wavy movement. Likewise here the natural leaf presents the motive, indeed in its full development at high noon, when the rays of the sun act thereon, and compel the same to certain bendings, which enhance the manifold effect of the shadows. There is found when several leaves are arranged in groups or bunches, an alternation in regard to the sides of the leaves turned outward. If this be not carefully executed, so that one leaf should have the form in which the other could be cast, but the peculiarities of the different sides be reproduced in the arrangement of the ribs as well as in the relief of the s surfaces. Soon the endeavor makes itself felt to even express mor shapely the basal form of the leaf, i.e., the geometrical figure forming its ground. The shape of the nucleus of the capital, thus the bell, is then an impelling influence for the f forms of the foliage only so far as the leaves lie thereon in their separate parts and bend below the edge.

Foliage of the later time.

Increased movement in the modeling as in the contours then

characterizes the foliage of the late Gothic capitals, so that the natural model is only recognizable in the character of the different outlines and also by the fruits connected therewith. The surfaces often bend very abruptly from each other or even appear imitated from diseased plants, show by their withering and recurved edges and points, and first of all show those rounds and swellings and depressions, in whose excess men long saw the proper nature of Gothic ornaments. Such a capital of the supporteng column is still moderately treated, from the f pulpit of S. Blasien in Mühlhausen is shown in Fig. 522. Another taken from the crossing piers of S. Maria's church there is that in Fig. 524, on which is still retained the arrangement of bunches of leaves, and only the leaves show this excessive modeling. There the incisions between the separate lobes of the leaves are evey deeper, as men began to seek generally the effect of shadows cast in these sinkings, and finally succeeded in giving the sinkings a power equal to that of the proper forms of the leaves, when they gave these definite forms like tracery. Finally even these forms were left and indeed to terminate them, the distinctness of the proper outlines of the leaves were neglected, when the points were allowed to combine from different leaves, and thus between them fish bladders or quatrefoil panels were obtained, but the proper character of the leaf was entirely obscured. Fig. 523 exhibits such a capital.

Different forms of capitals.

Capitals with little or no projection.

On the proper capitals of rounds in certain cases and for t the before mentioned reasons was the projection reduced, so t that the outward bending of the edge of the bell was lessened or entirely omitted, the body of the capital entirely corresponding to that of the column, and merely the astragal separating it from the latter. There the foliage can still be arranged in the same manner as in the actually projecting capitals, and consist of one or more rows of attached branches of leaves. Such capitals are found in the bitter chamber of the monastery of Haina (Fig. 526). A different form is conversely shown in the capital from Mühlhausen reproduced in Fig. 524, where the plan of the capital continues above the astragal in the capital and ends beneath the strongly projecting octagonal abacus (Fig.

(Fig. 524a), in whose hollow lies the branches of leaves of t the upper row. This conceals in such wise the transition to t the octagon, and at the same time forms a support for the edge of the abacus. Conversely the lower ones only have their stems attached to the nucleus of the cylindrical capital.

The comparison of the two last forms permits that of Fig. 524 to appear more justifiable, since the upper bundles of leaves also fulfil a real purpose, which entirely disappears in Fig. 526. Yet the effect of the latter is better, since the projecting leaves of the upper row present a substitute for the lacking edge of the bell, although an apparent one, therefore the effect of the older form of capital comes closer.

The just mentioned capitals lacking a projection of their o own body are everywhere in place, where the plan of the springing of the members of the arches harmonizes with that of the column or pier, as for example usually occurs in regard to the window tracery and of the jambs. Strictly taken in these cases the apacus is also superfluous, and the delineation of the ground line of the arch that alone concerns it, is effected by the foliage attached to the column above the astragal. The effect of the latter thereby is nearer the usual form of capital, because seen as a whole it terminates at top in a horizontal line. Capitals of this kind are found in the windows of t the southern side aisle of the minster in Freiburg in different forms (Fig. 525), further on the cathedrals of Chalons and Evreux. (Dictionnaire d'architecture, II, p. 533). More rarely is found a similar arrangement on the little columns at the sides of portals, as at S. Stephen of Mayence.

Capitals without astragal.

On some forms of capitals of the late period the astragal is omitted, and it is either replaced by the entwined stems as in Fig. 522, or the separate leaves are laid directly on the shaft of the column. Such forms will result from omitting the lower circle of leaves and the astragal in Figs. 524 and 526. Thereby in the first Fig. the leaves would only form a decoration of the abacus, and this character becomes one more important if their stems remain in the hollow a in Fig. 524., so that the entire form is represented as a union of the otherwise assumed triple form of the capital, in which the hollow a forms the bell, an ogee member the abacus and the lower surface the astragal

Capitals of the last kind are generally found in these simple churches of the 14 th and 15 th centuries, an which the octagonal basal form of the piers continue in the side arches, and in the simplest cases consist of a flat ended above by a fillet and below by a hollow (Fig. 445), but also usually take the form represented in Fig. 538, and in both cases may be covered by foliage or left plain. In a way the form represented in Fig. 527 is also to be counted with it.

The ornamentation of the members of such capitals is generally found in heads, indeed either naturalistic or combined with foliage (Note), and is also effected by entire figures, forms of animals, suspended shields of arms, inscriptions, etc. Forms of figures or heads are also usually found as actual supporters treated like caryatids; as on the beautiful fountain in Nuremburg, the heads in a sense are stuck on the shaft of the column and replace the capital. Just as the heads, the animal forms are usually interwoven in foliage, or their tails extend in form of foliage. Especially commonly reappear as in the keystone of Fig. 233 the representation of two animals with interlaced necks also on forms of capitals. If now an many cases the meaning of these forms to us is only possible by more or less risky hypotheses, it yet arises from the entire character of mediaeval art as well as the greater number of examples in which this is made entirely clear, that such a one was the basis in all cases, and that entirely removed from Gothic art was t the desire in so many works of modern art, to employ figure s shapes for themselves alone without any relation whatever, and even in frequent repetitions.

Note. Leaf heads according to Vilard de Honnecourt.

As an example of a capital with figure ornament may serve Fig. 528 from the second half of the 14 th century, from the church at Gottsbüren near Cassel. In the upper are placed the heads with a purely ornamental purpose, while those figures of a praying nun projecting from the shaft of the round in a sense s support the projection of the edge of the moulding above, so that both motives mentioned are found combined.

Capitals without ornament.

The need of economy or more frequently the striving for a c certain simplicity has sometimes led to the complete absence of all ornament. Capitals of this kind are found in the cathe-

cathedrals of Dijon and of Narbonne, in the foundation churches of Colmar and of Troyes, in the church of the Minorites in Cologne and in many other churches, particularly of the mendicant orders. In the simplest cases they have the form antirely harmonizing with that previously mentioned, so that the foliag merely seems omitted as shown in Figs. 502 and 529 from Dijon and Treysa. (The latter being a circular plan). The simple plain surface of the bell would then usually be animated by painting. Such an example is shown by the little column of the jam in the interior of the window of the choir of the Wiesen churc in Soest, where on these surfaces is painted light green scrol work on dark green grounds. That also the relief ornament receives such animation by alternating colors will be more fully explained at the proper place.

But the nearest substitute for the lacking ornament is afforded by the enhanced riqhness of the members (Figs. 530to 534) in connection with that in Fig. 503 and in contrast with the transformation of the transition from the polygon to the circle shown in Fig. 502.

Penetrations.

Generally it is the arrangement of these transitions, which offered to the characteristic striving after artificial penetrations in the later period of Gothic art repeated opportunities have changed the forms of capitals. The ground motive of these forms is the penetration of the cylinder by a square or polygonal pier capital formed about like Fig. 527.

Already from the beginning of the 14 th century is found a capital of allied shape on the southern side of the cloister of the monastery of Haina before the no longer existing fountain chapel. The pier is round, but the springing of the arch is shaped like a square set diagonally, two sides ofit extending in the profiles of the arches on both sides. The capital represented in Fig. 532 therefore affects the transition from the abacus a likewise having the shape of the basal form of a square set diagonally to the cylinder through the four sides of the pyramid b penetrating the latter, with which again bineath the angles of the square intersect the four funnel shaped corbels c. But the side surfaces of the latter are not smooth as shown by the plan drawn at d, but are divided by flat hollows, and their lower points rest on branches of leaves e. The-

Therefore the entire form still shows a certain relation to t the older form of the square, in a sense an application of the principle of penetration of the same, and is often characterized preferably by its freer treatment than the forms belonging to the later period, in which indeed penetrations of very different forms prevail as a mystery.

A shape of the last kind is shown by Fig. 533, that represents the penetration of a capital belongong ao an octagonal into a cylindrical shaft, so that the lower octagon of the capital is inserted in the circle of the cylinder, and the little points make the transition. The latter become richer when the capital is formed below by combined members instead of a curve, for example as given in Fig. 534. The latter capital is shaped on a hexagonal plan, but the transition of the latter to the cylinder is placed under the astragal, so that the body of the bell affects only the increase of the projection. The plan is seen in Fig. 534a. The members in elevation thus make the transition from the hexagon inscribed in the circle of the cylinder to that circumscribed about it, so that between both hexagons lie the intersections, than can easily be constructed. In Fig. 535 is then the transition from the circle to the octagon is replaced by a simple slope instead of a moulding, and this extends around the circle of the shaft, hence forming a part of the surface of a cone. Thereby arises the intersection of the cone with the octagonal prism; Fig. 535a shows the form in perspective.

In the same manner would be formed the transition from a compound ground form to any simpler one, thus for example from the octagonal pier to a square capital, or from any ground form to one set diagonally, and also finally and generally in an irregular way are all transitions from one to the other.

The further execution of these forms is suited in a higher degree to the working of wood than that of stone, and therefore also finds its chief employment in the treatment of wooden stalls and in furniture.

Prismatic capitals and the like.

In Fig. 535, which represents the capital of a round belonging to the church at Immenhausen, is omitted all reference to the original bell form, and the body of the bell is replaced by a short octagonal prism. The surfacer of the prism then give

opportunity for richer treatment. The simplest case would then be to form rectangular panels recessed by a moulding, whse ground is then occupied by a rosette or other foliage; or these panels might receive a form very like tracery, as by cusps inserted in the sides of the rectangle, as on the middle piers of the church at Bornhofen, and further by any more complex pattern. Such richer forms are more rarely found on actual rounds than on those modern columns near the eye, which are placed as supports of statues or any more ornamentel arrangement, like a shrine, finial, or as a starting point of a corbelling as under pulpits, bay windows, etc. Here is then found sometimes the almost overloaded artificial arrangement, that the tracery is perforated and within the surfaces thus formed as in a cage swings a body of capital shape from the upper abacus of an actual capital beneath it, so that the object ornamented by tracery represente in a sense the pedestal of the figure or an intermediate, as Fig. 537 shows in section.

With the forms of this kind are to be counted those extremely rich capitals of the piers of the cathedral in Milan, that are likewise formed by the insertion of prismatic bodies, whose side surfaces represent niches arranged beside each other, separated by finials and crowned by gables, but thereby the proper laws of the formation of capitals are just concealed by their magnificence.

Arrangement of the plans of capitals on compound piers.

Capitals on compound piers of the early time.

On compound piers each round receives its separate capital with independently expressed ground form of the abacus.(Note). The junction of these different capitals is thus arranged according to the plan of the pier and that of the different abacuses. According to those oldest ground forms of piers with rectangular projections and with rounds in the angles reproduced here, therefore is also the general form of the capitals of t these rectangular recessions. For oblong bays of the cross vault, seldom for square bays, sometimes appear modifications, that the square capitals under the diagonal ribs stand in the same direction as those set diagonally. So that generally there is soon with a freer treatment of the pier or group of shafts in the direction of the axes of the square or polygon of the abacus concerned. In the direction of the arch may be placed

either a side or an angle of the folygon. For the good effect of the arrangement it is essential, that the sidesof the polygon does not meet in two acute angles, and that reference thereto the cboice and location of the polygon requires above all a good general form as more important than a rich ornamentatio

Note. Exceptions to this, as for example they appear on the columns of the jambs of portals, will find their explanation at the proper places.

Already for stepped forms of piers cannot usually be expressed all little members in the total form of the capital, and the same condition is also found in the rounds connected by hollows in the earlier period, and the hollows end properly beneath the abacus of the capital. In the same manner like the abacus, also the angle leaves of the earlier form of capital grow together, indeed so that their ends entirely disappear as shown in plan in Fig. 539, or two such supports join in the s same leaf knob (Fig. 540).

Only the astragal sometimes continues around on the hollows, which then extend above it and stop beneath the capitals of t the rounds, as shown in the same Fig.

Capitals on round piers with little shafts.

On round piers joined with four rounds the nucleus of the p pier receives a capital, which intersects those of the rounds and either has the same projection as they, as on most German works, a larger one on the older French cathedrals, or a smaller one if the nucleus of the pier is only surrounded by the abacus, as on certain Westphalian churches (also see S. Jacobi at Einbeck, Fig. 428).

As a rule in Germany, the pier capital remains in the round form. But by the animated projections of the shaft capitals, even if the latter remain round, the rather stumpy appearance of this ground form is modified, and passes into the more distinct effect of the square set diagonally (see piers at Wetter in Figs. 427 and 510).

Yet the effect will also be more tasteful here, if the capitals of the rounds take a polygonal form, since usually the contrast of the short sides of the polygonal and circular parts is very happy. This arrangement is already found in the nave of the church at Haina, dating from the second half of the 13 th century, that is about the same at the old cathedral of Dijon

of the church of the Minorites at Höxter (Fig. 427 right and Fig. 429).

But likewise the pier capital may assume a polygonal form and be combined in the same way with polygonal capitals of the rounds. Very happy in this respect is the arrangement of the pier capitals in the cathedral at Rheims, where the nucleus of the pier bears a capital in the form of a diagonal square, whose angles combine with the four octagonal capitals of the rounds

Capitals on compound piers of the later time.

On the compound piers of the middle and late periods as a r rule is found only a very small and sometimes no projection of the plan of the arch, and accordingly only a small projection of the capital. Since now the proportion of the widths of the hollows to the diameters of the rounds has also increased, then also the extension of the hollows under the capitals of the r rounds is no longer possible. Accordingly the capital follows the entire plan of the pier, when also the line of the hollows is accompanied by concentric arches. But there it may be necessary to replace the latter arches by straight lines to establish continuity. An example of this kind is shown by Fig. 438. Since where the hollows as members of the pier continue as slightly modified or unchanged forms in the members of the arch, each greater projection of the capital in them will be superfluous, and accordingly the capital extending around first assumes a simpler form, while the projection of the bell as w well as the foliage thereon is omitted.

That complete agreement of the hollows of the pier with those of the arch, the capital in the former becomes superfluous, and it results that the arrangement common from the middle of the 14 th century onward, whereby only the rounds have capitals, which stop horizontally in the hollows continuing in the arches, conversely to the hollows and angles of the members in the older style, those at parts representing proper angles of the nucleus of the pier stop vertically under the capitals of the rounds.

The form mentioned then makes the transition to the piers w without capitals.

Elevation of capitals of compound piers.

Different heights of the capitals.

In general is the rule correct, that the upper edge of the

capitals denotes the base line of the arch. Following this therefore leads to a complication of the rounds or little columns everywhere, and especially to an unequal height of the capitals of the rounds, where the base lines of the arches lie at different heights. Such examples occur in window tracery, when the base line of the tracery falls below that of the arch. But it more necessarily results on vault bays with strongly differing lengths of sides, first already on the vaults of every polygonal choir, where a separate round is arranged for each rib. When here the side arches and the diagonal ribs must commence on o one base line, then as previously stated, their crowns must either lie far below the crown of the vault, or their forms must become extremely pointed. Both will be avoided by raising the base line of the arch of smaller span, and therefore according to the preceding rule the capitals of the rounds under them.

By these unequal heights of the capitals will be increased the animated effect of the whole, as well as if the capitals of the different piers filling the window in the space between the rounds of the side arches again fall at different heights as required by the forms of the tracery.

Separate stilted arches.

But for all rounds the same height of the capitals can be obtained by a corresponding stilting of the arches of lesser span. But diagonal ribs and side arches rest on a common round, then also stilting would be avoided by the arrangement of smaller rounds set on the capitals for the side arches, as for example in the choir of the church of the Minorites in Duisburg.

Similar conditions result on the capitals of the detached p piers with unequal lengths of sides of bays. Thus for a round pier connected with four rounds and separating two aisles of equal height, the capital of the round supporteng the diagonal rib, whose height is fixed by the base line of the rib, in the simplest case extends around the entire pier, and the narrower dividing arch would be stilted, indeed this arrangement becomes a necessity, if as in Fig. 427 the diagonal rib, whose span exceeds that of the cross rib, rests on the nucleus of the pier, therefore determining the height of the capital on the latter. On the contrary, if the nucleus of the pier only supports the dividing arches, its capital and the rounds belonging to it a also in the base line of the dividing arch, can therefore be

placed higher than the capitals of the rounds bearing the cross and diagonal ribs. Then the higher capital of the pier will cut into the continuation of the vertical surface of the compartment lying in the profile of the rib. Still more easily would be found an arrangement of the last kind in connection with t the plan of pier represented in Fig. 426.

An adjustment of both systems is found on the round piers with four rounds of S. Blasius in Mühlhausen. Here at the height of the base line s of the diagonal and cross ribs, the capitals decorated by foliage extend around the entire pier and on them rest the dividing arches with a simply profiled plan in a manner, so that the lower end of the profile stands on the round, as Fig. 451 shows in perspective. The dividing arches are stilted high, but the weight of their actual base line is indicated by a slightly projecting moulding a intersecting the hollow of the profile of the dividing arch, so that the proper capital of the pier rests on a second lower pier, which bears the dividing arch.

Separated capitals of the rounds.

The arrangement of the capitals at unequal heights occurs e even more in those piers of the later period chiefly composed of hollows, on which only the rounds have capitals, as they a are found in extremely rich forms in the choir of S. Ouen in Rouen. Here rises each of the rounds, which form the body of the pier in their construction by means of hollows, independently of the nearest one, so far as the base line of the arch requires and then bears its separate capital, denying all relation to the entirety of the pier, therefore being only in a certain relation to the diameter of the round. We have here n not only unequal heights, but even unequal heights of the separate capitals, and consequently a loss of all independence of the pier, and the transition to the form without a capital, c continuing in the members of the arch.

From the rule given above, that the base line of the arch determines the location of the capital, there is also found the exception formed by the stilted arches, there is still a second that consists in this, that the capitals in a sense are taken from the height of the arch, when they range in the base line with the under edge of the astragal. This condition is most

distinctly expressed in the smaller arcades of Notre Dame at Dijon (Fig. 542) or the windows, triforiums, etc., where the arch lines above the clear opening are full pointed arches, while the concentric plan of the shaft continued through them into the arch represents a broken arch resting on the capital. The entire form harmonizes its nature with the change of the springing of the arch shown in Fig. 273, as of use, that first the intersection of the round is avoided and second the little column receives a more slender form. An application of it to a pier composed of several columns would lead to an unequal a arrangement of the heights of the capitals on them.

Height of capitals and of ashlars.

On the proportion of the entire height of the capital, to the diameter of the column or of the projection as well as of the other parts to each other, no determination is possible. An eye trained by the study of old works in connection with the most accurate understanding of the special conditions can alone find the right one in a given case. If already in general a larger column rejuires a higher capital than a slender round, a direct proportion of the height of the capital to the diameter of the column does not exist. In ordinary conditions the capital is cut in a course either with or without the abacus, therefore the nature and size of the material already give certain starting points and limits. Execution in a single block is therefore first required for a compound pier having the same height of capitals for the rounds and intermediate members without regard to their different sizes, so that also for a round pier with four little shafts their capitals with the same heights continue around the nucleus of the pier as shown in Fig. 510.

When extreme conditions of the size of the whole allow the height of capital possibly obtained by one course not to appear sufficient, and permit the execution of the capital in two courses lying above each other, no construction is yet known to us in Germany, where this construction is expressed in the form of the capital. On the contrary forms affected thereby are found in certain French works. For when the necessity of a greater height of the capital concerned only the nucleus of the pier, the lower course was only utilized in the capital for the latter, but for the shafts and the continuation of the shaft occu-

occupied it up to the capital formed in the upper course, as in the cathedral of Amiens. On the contrary there is found in Rheims beneath the capital of the rounds made in the upper course, a second slightly projecting one, whose decoration remains without any connection with the upper one, and it lies beneath the astragal of the latter, which continues in the foliage of the proper capital of the pier, while the astragal belonging to the lower capital extends around beneath the capital of the pier. But since the astragal belonging to the upper capital of the round has only a small projection, the entire form only differs in principle and not in effect from that common in Germany.

In contrast to the form of the capital of one block or of two lying on each other, in any case must we return to the peculiar arrangement of the older Westphalian works, whereby capitals were only arranged for the rounds, but whose abacus extends concentrically around the round pier. This arrangement had its origin in an execution of the pier in smaller materials, which were then bound together by capitals formed of longer cut stones, so that the piers lack combination by an united capital; accordingly it forms the transition to the form of the pier in brick construction, to which we shall return later below.

Bases of columns and of piers.

Relation between capitals and bases.

The base has the purpose of continuing the pier to the foundation, hence providing an enlargement of the section and a t transition from the more complicated and smaller area of the former to the square and larger form of the latter. Accordingly the base has in common with the capital the projections and transitions. Statically a projection of the capital and base satisfies similar conditions. Since in a quiet body all forces occur in pairs, at every cross section of the support the weight of the upper part is opposed by an equal reaction of the lower part. If a projection exists, i.e., if the compression is transferred to a larger area, then is it the same under the effect of these two forces, whether the projection is above ((capital) or belon (base).

Since when capital and base are under like conditions, i.e., where an entirely definite compression is transferred to a projection of distinct form and size, it can accordingly be j

justified to form them exactly similar, which sometimes occurred in the Romanesque period and more frequently in late Gothic.

But as a rule the conditions for capital and base are not exactly similar, rather their functions differ in more than one point, so that a different architectural treatment is required for both.

First in massive piers the compression at the top of the base is considerably greater than above the capital, since on the capital is only the overload, while on the base further rests the weight of the pier itself.

Then on the capital are set much divided members, while on the base it attains only a larger simple area.

Freely projecting ornamental members that are in place on t the capital must be avoided on the base chiefly for reasons of suitability.

The capital is seen by the observer more obliquely than the base.

Finally an independent pier already has much an effect as a separate form, that its upper termination must express not only support, but also a crowning.

All these requirements were taken in the most varied ways by the middle ages according to the conditions; capitals and bases accurately show in a high degree the refined stylistic feeling, that permeates all the better works of the middle ages. The Gothic knows no ready made column, that like the turned wooden pieces in a child's box of building blocks can be employed here or there at pleasure; it rather creates for each place a support belonging there.

Members of the base.

Consider first the form of the base of the simple column or round, then here as on the bell of the capital, the nearest purpose is an enlargement of the basal form, which by the base mouldings extending concentric with the circle of the column is formed its proper base. But in regard to the shape of the latter the ground form of the mass of the base at first remains without influence, for it is similar for the square, circular or any polygonal form of the latter.

At first the base in many older works is still found entirely corresponding to the Attic type; thus on the round bases in the choir of the church at Volkmassen (Fig. 543). But to the

idea of spreading the pressure from above underneath as oppose by the form of the torus in a semicircle, that expressed a similar function of this member above and below. Since already th Greeke partially departed from the pure circular line, and partly expressed these conditions by the section of the torus accordind to b in Fig. 543a instead of like that at a, it found in Gothic art a still more emphatic accenting by the flattened form entirely differing from the circular line. On steep bases the torus takes the form of Fig. 544, or from low ones those of Figs. 545 and 546 (from the monastery at Walkenried) or of Fig. 547 (round pier from Notre Dame in Dijon). But the shape of this line is of endless variety, and it is about between the limits shown in Figs. 547 and 548.

The upper torus, which is still separated from the shaft of the column by a fillet, then rests directly on it, indeed with a continuation by a curved line from the distance a b in Fig. 547, whereby results a sinking, from which again sometimes a splay rises to the shaft, yet it also generally takes the form of a flattened curve, or of one pressed in at the middle, as shown by the profile of the base in the church at Mantes represented in Fig. 548. The latter line is capable of the most varied shape, according as the convex or the concave principle predominates. Both toruses are separated by a deeply cut scotia as in the Roman Attic bases, that either is combined with little angular members as in Figs. 546 to 548, or as in Fig. 551 directly cuts into this. The lower margin a of it remains either as in Fig. 548 within the vertical drawn through the extreme outer point of the upper torus or projects beyond it. Likewise the lowest point of the scotia lies at the height c (Fig. 547) or may sink below it. This generally the line of t the scotia itself is very variable, and its purpose is chiefly to be sought as producing a very deep shadow, thus animating the effect of the members by the contrast with all soft shades of the flat profile of the torus.

A definite construction of such a profile is impossible as in all similar cases. As for what concerns the proportion of the height to the projection, both are sometimes equal, sometimes the first slightly exceeds and sometimes the latter. Bases lying above the eye of the observer already in the Romanesque time were steeper (Figs. 543 and 544) than those below it

For the proportions of the different members to each other it must be characteristic, that the lower torus occupies at least half the height of the entire member. In Figs. 549 and 550 we attempt by aiding lines to give only some general starting points for indicated constructions.

There a simplification of the form of profile just represented was then developed, peculiar to the middle and later periods, when men came from that to omit the fillet over the scotia, as having no structural importance, and indeed when either the upper torus was omitted or the hollow, whose size was also reduced and had lost its distinctness by the loss of the fillet. By the first way was reached there Fig. 550 through Figs. 551 and 552, on the latter after widening the hollow and reducing the lower torus through Figs. 553 to 554 and 556. The former shape is already found in the boss form on the little coluns on the jambs of a portal in the south transept of the cathedral at Mayence, dating from the middle of the 13 th century, then fully developed at the end of the same century in the nave piers of the church at Haina, and lonsequently has a better effect than the second, that from the beginning of the 14 th century is found in the church of the Minorites in Soest, and then by reduction and omission of the torus disowns all characteristics of the base as such, passes from Fig. 356 for example in the cathedral of Frankfort. But the form of the last is in exact relation to the general arrangement of the later forms of bases, particularly of the transition from the circle to the square or polygon of the mass of the base.

The base with the part of the plinth lying beneath it is always wrought from one block. The low printh of the earlier Romanesque column soon becomes a higher prismatic body.

Subdivision of the height and members of the base.

The proportions of the height of the base are just as flexible as its projection. The total height is from 30 to 60 cm, or sometimes amounts to more. The usual height requires two courses according to the ordinary dimensions of the cut blocks, and this division in two perts is expressed in a projection of the lower part, made by a wash, cove or by a compound member. This division into two parts is then almost typical for the r richer forms of bases, even where the entire base consists of a single block, as on the little columns of window jambs and

With the flat base forming the margin of the upper stone, t the members of the lower block usually contrast by their steep direction that give a decided stamp to the outline of the entire base. It consists mostly of a scotia, that forms both divisions of the base by fillets, chamfers or roundings, more rarely is entirely simple; since it is chiefly seen in elevation, its effect must be obtained by a sharper separation of the upper torus from the body of the base, a sinking below the horizontal extension, as at a′ in Fig. 548. Figs. 548, 558 and 564 give different examples of it.

In the later time of Gothic art men began to make these opposed directions of both members less prominent, making them p parallel or reversing the proportions and forming the lower one flatter than the upper.

Of the two divisions of the base separated by the lower member, as a rule the upper is higher, yet even this difference also alternates, sometimes disappears or becomes opposite. The last condition leads to an always lesser height of the upper division and finally to a combination of both members. For French works of the 14 th and 15 th centuries is characteristic the form in Fig. 557, resulting from the simplification and c combination of both members of the base, and it is repeated w with tiresome monotony.

Square bases.

For the proper body of the base as for the abacus of the capital, the square form is indicated for the same reasons. Indeed it is nearer than there, since it is already given by the form of the foundation. The upper surface of this square is then c concentric with the base accompanying the circle of the column, indeed first in the same manner as in Fig. 342, the edge of t the edge of the bell is placed beneath the abacus, so that the extreme circle of the base is circumscribed in that square. The remaining four triangles lying in the horizontal surface were already in Romanesque art covered by corner leaves formed with extreme diversity. for static and esthetic reasons. The arrangement of the latter was continued during the 13 th century in France as well as in Germany, for example in S. Blasien in Mühlhausen, in the aisle of Freiburg cathedral, and even on the columns of the rood screen in the cathedral at Lübeck (Fig. 562). At first are they found in that very rich variety peculiar tothe

Romanesque style (see the usually recurring form in Figs. 559 and 560, then they take a strongly recurved shape of leaf found almost everywhere (Fig. 561), so that even this monotony is characterized as vanishing. Fig. 558 shows the corner leaves on the bases of the piers of the cathedral of Rouen.

But since such a leaf could not cover the remaining area with mathematical accuracy, then according to the principle of Gothic art that allows the horizontal surface only as a bearing or floor surface, a chamfer of the upper edge of the square plinth of the base became necessary. Thisi chamfers denoted by f in Figs. 549 and 550 then extend beneath the torus of the b base, so that the latter projects at the middle of the side of the square beyond the chamfer. By the increase of this chamfer, which then usually changes into a hollow, was given a means of avoiding the horizontal triangular surface, or of reducing it to a minimum, and thus the covering leaves were omitted. Of t the contemporary bases in Figs. 545 and 546, the former has covering leaves and the latter has not.

By the increase of this chamfer mentioned, there increased in the same proportion the projection of the torus and thereby the possibility of its being injured. Therefore this member frequently did not project beyond the entire sides of the square, but only about one third of it, to e and f in Fig. 564 showing the way, so that between e and f the vertical surface remains and extends under the torus. The entire arrangement is preferably formed, if the circle of the torus projects a little beyond the square body of the plinth as assumed in Fig. 564.

An increase of this projection then leads to the above contrasted proportions in plan, so that the square of the plinth is inscribed in the outer circle of the base, whereby the edge of the torus forms a projection at each side of the plinth, w which makes necessary a special support at the middle. The latter is then obtained by a corbel remaining from the mass of the plinth, which as a rule is shaped like an irregular part of a polygon, producing a wider base, as shown by a b c d in the upper half of Fig. 565a. Thereby only the part a b c of the torus forms a free projection with a horizontal surface beneath.

But the size of this surface, as well as of the before mentioned corbel a b c d may be reduced, if the square of the plinth projects at the angles beyond the circle of the base, as at

f in the lower quarter of Fig. 565a. But these projecting angles of the plinth then first are broken beneath the base as at g h i or k l m n as in the right quarter of the same Fig.,and above the lower member of the plinth by a wash made in its original form, so that the plinth receives the form represented in elevation in Fig. 565. Likewise with the arrangement of the corbels mentioned with that represented in Fig. 564, the horizontal member breaking the angles of the plinth were connected. Such bases are found in the church at Colmar. The corbel mentioned under the edge of the base generally received a simple form. That given in Figs. 565 and 563 is almost typical for it. On the church of S. Thomas in Strasburg as well as on certain piers of the minster they are found replaced by leaves. Fig.565b A peculiarly rich form of plinth comprising most shapes mentioned is then found in the church at Gelnhausen (Fig. 563). Here the circle of the base projects a little beyond the middle of the sides of the square plinth. But the latter is divided by a recess, in which is visible a plinth in a quatrefoil plan set under the circle of the base. Above the lower plinth this sinking then extends into the square, while the moulding formed extends horizontally.

Thereby the sides of this recess cut beneath the base above form a projection from the circle of the base, which is covered by the corner leaves, just as the projection of the quatrefoil permits the arrangement of the before mentioned corbels. The effect of the entire form is extremely vivid because of t the varied shadows, that result from the rich alternation of the ground forms, and it is further of interest, that it properly is represented as an intersection, which results from the system of the square plinth transferred from Romanesque art with the round form predominating in the neighboring early Gothic works in Hesse and Westphalia.

By the projection of the base beyond the plinth given in Figs. 565 and 565a results both the origin of the twofold shape for those smaller bases, that are formed b: a single cut stone, from the necessary mass of the latter. It expresses this nowhere more clearly than on the bases of the chapel in Paris made od two layers and accordingly divided in two parts, on which the upper base with regard to that projection above the joint extends with a wash, so that the entire base is really triply

divided.

Instead of the recesses at the angles given in Fig. 565, these may be chamfered, by which the character of the square ground form given in the return at a in Fig. 565 always continues. Generally the skuare ground form of plinth recessed from all bases removed from human contact is most suitable, as on the little columns of window jambs, mullions, etc.

Polygonal bases.

But for all bases standing on the floor, is for all piers of vaults and shafts the square form has certain disadvantages in consequence, because by the wide projection of the angles they make a large area inaccessible, and are easily injured by repeated contact with the rectangular angles. Consequently it was next to chamfer also the plinth like the capitals and finally to adopt the polygonal ground form. First are the singme round or polygonal piers, in which also the forms of the transition to the square shown in Figs. 564 and 565 require a considerable magnitude and therefore demand an inconvenient height. In a f far less degree can the polygonal square form be obstructive on the bases of the rounds, and at the same time for piers composed of separate rounds with the combination of the separate square plinths, when those supporting the diagonal ribs are set diagonally, and a polygonal ground form easily results. T Therefore are sometimes found in the same work the round nave pier with the octagonal, the rounds and cluster of shafts witth square bases, thus in Notre Dame of Dijon.

Likewise also the separate square bases of the rounds can be combined on a polygonal support.

The adoption of the polygonal ground form for the plinth renders more easy for the considerable diameter of the column the formation of that transition, and makes it superfluous for a smaller diameter, since then the projection of the edge of the round base over the sides of the polygonal plinth is so small, even when the polygon is sincsibed in the circle, it can remain without support.

Only for detached piers can be produced a regular polygon, while on all whether a pier, a wall surface or below rounds joined together, the junction of the plinths sometimes presents the formation of a regular polygon, permitting only a square to originate from the corresponding division of the circular

segments remaining free. Thus in Fig. 566 the polygon of the plinth of the round resulting from the division of the curve into five parts, would be irregular in completion.

The different forms of the transition shown in Figs. 564 and 565 also sometimes are employed on the polygonal plinth for d decoration. Generally are found particularly the cuts taken from the angles of the polygonal plinth as in Fig. 565, and by the stronger accenting of the angles, they accent the vivid effect of the whole.

Round plinths etc.

The previously mentioned round plinths likewise in most cases consist of twofold projections characterized by members, and the forms of the members are indeed the same as for the square and polygonal plinths. Only the proportions change so far, that while on the latter the torus terminates the proper base a and the chamfer below belongs to the plinth, here a decided separation is absent. Hence the torus ending the base is combined with the chamfer, thus receiving a recurved shape as in Fig. 567, or is also omitted and the mouldings of the base end below with a hollow or chamfer as in Fig. 556.

What is said here of the round base is likewise true of all that have no transition from one ground form to another, or where this transition is formed by the moulding itself. This last arrangement that corresponds to the form of capital shown in Fig. 503 is shown in perspective in Fig. 568. The transition from the round to the polygon more easily occurs in the scotia of the base than in the bell of the capital, since the former becomes horizontal at a, so that as given in Fig. 568, only the insertion of the triangle a b c in the horizontal plane is necessary to effect the transition. In a similar way on small wall columns the plinth mouldings sometimes begin with a little horizontal plane (Fig. 568a) that makes the transition to the polygon.

A combination of the plan of the round with that of the polygonal plinth is indeed shown sometimes, chiefly in forms usually occurring in the 15 th century, where the plinth remains round, but the polygon has the flutes cut for a short distance below the base, that again by a wash pass into the circle. But sometimes this fluted body also passes into a polygon instead of the circle of peculiar form, such plinths are shown on rec-

recurved rounds as shown by Fig. 567.

Here the moulding of the base extends around the plan of the round, so that the little projection a intersecting the moulding has the width b c at the plinth. The arc b d of the plinth is then divided into three parts and each of these parts and also the breadth b c is hollowed in a flat circular arc, so t that the surface c b e f d becomes the form of the plan. These concave surfaces then stop below the base at a in Fig. 567, and at b pass by a wash into the corresponding polygon, which receives an entirely irregular form and by another wash broadens into the lower division of the base.

Different forms of plinths of the late period.

The lower plinth is then often entirely omitted on the smaller columns and rounds, while in the contrast between the fluted and smooth parts of the plinth is thought to be found a substitute. This contrast will then be increased, if the angles of the fluted portion instead of being vertical, rise spirally as in Fig. 569. Sometimes these spirals also extend from one point to both sides, thus crossing and forming little lozenges, within which the flutes appear, or from the same points also rise vertical angles, so that the number of intersections is increased and little triangles are formed. Or the edges are carried vertically for a short distance, then passing into the direction of the spirals and later back into verticals, or the surface of the cylindrical portion has scales; in brief the Gothic art of the 15 th and 16 centuries developed an inexhaustible diversity in the mode of treatment of just this part of the architecture, as proved by a rich choice of examples to be found in Kallenbach and Heideloff.

If even the modes of treatment described produces a puerile effect when applied to plinths of larger piers and rounds, yet it is still in place whenever very near the eye, on which it usually falls and for a longer time, as for example especially on the little columns and rounds on the window jambs of secular buildings.

An application of this ornamental motive to actual plinths of rounds is found on the piers of the church of S. Katherine in Eschwege (Fig. 570) dating from the second half of the 15 th century. Here beneath the round base is a fluted part, which passes again into the circle farther down. This transition is

not made by the usual wash, but by round arches falling at both sides to the circular line. The lower cylinder then passes through the lower moulding of the plinth into the octagon according to the way shown in Fig. 568. A similar form is shown by the plinth of a round in the choir of the church at Immenhausen in Fig. 571, on which the transition from the octagon with concave sides beneath the base into one larger and with straight sides is made by angular gables over the sides of the latter, while the proper twofold division of the plinth is expressed by a moulding extending around below those gables.

In all these arrangements, what is sought is not mistaken, they pass from the simple beauty of the older art, but they are still in a thoughtful way derived from the nature, with simple means producing an almost rich effect, and can serve as valuable starting points for the development of various forms of details, particularly on works of secular architecture.

Socle of the plinth.

Besides the already often mentioned two parts of the plinth, there is also sometimes found a socle or step on which rests the plinth, like the upper course of the foundation. The ground form of the simple square is however seldom shown, as a rule it is replaced by another form corresponding better to the entire plan of the plinth of the pier and representing a certain simplification. Accordingly is first of all the simple square set diagonally as in the church of the Minorites at Höxter (Fig. 572), or with clipped corners, also with four squares or octagons projecting from the angles, that gives the ground form. The additional area of this socle generally remains horizontal with simple sides and is rarely occupied by a wash, on which stand the plinths, like the rounds of the Liebfrauen church in Frankfort, Fig. 574.

Simpler is the form when the socle at the same time forms t the lower division of the plinth, or when the latter assumes a form differing from the plan of the upper plinth, simplifying the ground form of it. Such a form is shown in Fig. 573 from the Minorites church in Cologne. Here the plinth is a square set diagonally with clipped corners corresponding to the octagonal sides of the plinths of the rounds set on them, so that the surfaces f lie in the horizontal plane.

On the plinth of a round represented in Fig. 574 from the L Liebfrauen church the bases are round and then extend afterward in the plinth.

Use of the plinth on piers of compound plans.

Stepped piers.

As for what concerns the different arrangements of plans for piers or rounds of compound plans, then all that was said of capitals is applicable with few modifications. On the older stepped compound piers with rounds in the angles and on the outer sides, such as are found in Strasburg, Rouen, etc., the plinths of the rounds are square, are again found at right angles with each other, thus reproducing the ground form of the nucleus, which itself remains without plinth and rests in the angles on the plinths of the rounds as in Fig. 558.in Rouen. The members enclosing the angles of the nucleus of the pier pass again into the square form above the plinth of the round. This arrangement suffers the next modification, when the plinth squares of the rounds bearing the diagonal ribs are set in the direction of the latter as in Gelnhausen, Freiburg, Mantes, or when the plinths of certain rounds are polygonal instead of s square, or when all plinths are polygonal. The general form w was richer uhen the members of the base also continued the stepped nucleus, as on the piers in the transepts of the church of the monastery of Haina, arranged as in Fig. 421.

Round piers with rounds.

For round plans connected with four rounds, the same base extends around the round nucleus and the rounds. Then all plinths are either circular or those of the rounds take a square or polygonal form and unite with the round plinth of the pier. On certain works are also found the arrangement, that only the r round plinths of the rounds are divided into two parts, but the pier is only surrounded by the lower member of the plinth, and indeed this occurs particularly on the piers of those Westphalian works, whose capitals are formed according to the same principle before explained. Thus generally a certain harmony of the ground forms and the arrangements of the plinth and capital is usual, yet is not exactly to be regarded as a rule. Likewise also the plinth if the nucleus of the pier usually assumes a polygonal plan, and even the diagonally set square as in Rheims. The octagonal plan in Fig. 570 led to a peculiar

treatment. Here the greater differences between the circle and octagon caused by the greater diameter of the pier prescribed a magnitude for the plinth member forming the transition, unsuitable for the smaller plinths of the rounds, hence the different form of the latter, which then intersected the former. This inequality of the plinths of the pier and the rounds is found however in much earlier works. Generally the proportion between nucleus and rounds is so peculiar, that both arrangements as well as the similar base or plinth enclosing both as well as the difference between them can be justified.

The same combinations of the ground forms result on round piers with a group of rounds, of which we have given an example in Fig. 426. Just in the given case are the plinths of the rounds with their sides in the longitudinal direction, but the plinth of the round pier is an octagon, while on the pier of similar ground form the cathedral at Besancon the nucleus has a round, and the rounds have square plinths, yet so that the plinths of the rounds under the diagonal ribs are placed in t the direction of the ribs.

More easily than for the transition from the round pier with four rounds to the octagon of the plinth is made that for the round pier with eight rounds. This can either be placed so that the edges of the octagonal plinth are visible between the plinths of the rounds, as in the church of Colmar, or it is set d diagonally, when only the sides of the plinths of the rounds are visible.

On compound piers of the middle period, whose rounds are connected by hollows or by richer members, there are found different arrangements of the plinths.

Compound piers of the middle and later times.

First the members of the base surrounds the different parts of the plan of the pier parallel or concentric. With a smaller size of the hollows only the upper and less projecting member of the base can extend around, while the outer member of the bases of the rounds and also the plinth intersect, so that the hollows disappear in the plinth. But as a rule the hollow is also not expressed, where by its size would be possible, since the recesses produced thereby in the plinth itself would be too narrow. Then the upper member of the base already extends

before the hollow in the direction of its chord. What concerns the carrying of the moulding around an ogee member, this cannot be carried around the added edge in a concentric arc, but according to an approximate straight line or curve (Fig. 5-7), w where the middle part of the curve lies at c′.

Also as now on compound piers with a stepped nucleus only t the rounds have plinths, on which are set the angles of the nucleus (Fig. 558), the same system is also found used on these later plans of piers, on which the hollows and some intermediate members represent the nucleus of the pier. Only the form will here be the more striking, since the plinths of the rounds do not combine, but between them are allowed the hollows and fillets or members, then extending with them to a common plinth. Fig. 574 shows such an example from the Liebfrauen church in Frankfort, which is thereby still simply represented, so that the rounds yet have equal diameters, and therefore equal plinths. But since the separate plinths belong only to the rounds and not to the members, and their connections with them are o only represented by the common socle, by which could then be made the combination, if the plinths of the rounds were unlike, it is next to shape the plinths in proportion to the unequal sides of the rounds. Thus for example if we conceive the fillet a in the plan (Fig. 574a) to have a round, this would receive a smaller plinth similar to the larger ones, and thereby the diversity of the separate forms of plinths would be enhanced according to the scale of the members of the pier.

But almost inextricable will be the complication, if also the nucleus of the pier represented by the hollows receives i its separate low plinth, which is intersected by the plinths of the ogee members and prismatic bodies then terminating on a common socle.

Also as the latter form now resultsbecause also the hollows receive their separate plinths, so that one yields to them with the same right as to the rounds, then proceeding in the opposite direction, so that also for the rounds are omitted the plinths of all parts of the plan stop on a wash, which rises from the edge of a regular socle, generally shaped to correspond to the plan of the pier.

Thereby originated the forms of plinths occurring already in

the Wiesen church in Soest in the 14 th century and in the nave of Erfurt cathedral in the 15 th century. In the former the p plan of the pier forms a circumscribing square (Fig. 440), and in the latter the corresponding octagon is the ground form of the socle, from whose edge rises the wash. In both cases is then lacking the extension of the ground form, at least in the recognized outline of the whole, thus an essential requirement of the form of the plinth. Further the transition from the rich plan of the pier to the simple one of the socle by a wash is yet formed in a powerful way and finally the effect of the whole is dry in even a high degree, as that of the one previously described is complex, and entirely inferior to the quiet beauty of the lines of a plinth formed according to the earlier method.

Yet this affected form must not be too lightly esteemed. The entire necessity for its formation was given as soon as the rounds and the nucleus had been fused by members into a continuous entirety, instead of shaping each part according to a definite ground form, and their homogeneity was only expressed by their position. Thus in the early piers (Figs. 419 to 430) each of both parts can be conceived as existing for itself, or rather after removal of the rounds the nucleus still retains an independent ground form, while already in Fig. 438 such a separation by the removal of the rounds leaves the nucleus as a mutilated body. The lacking independence of the nucleus permits a widening of the hollows, an entirely capricious form, which finally scarcely deffers from any other profile of a moulding, and thus also permits the forms of plinth last mentioned.

Intersections.

And also the penetration of the more or less compound body of the pier by the cone or pyramid now further forms the theme, that the more ornamental forms of plinth in the late Gothic v varied with inexhaustible variety. As in Fig. 574 the transition to the cylindrical socle is formed thereby, so in general all transitions from one ground form to the other is thereby made possible, and also thus is affected the extension of the basal forms of plinths by these transitions.

In the right half of Fig. 575., let the inner rectangle with concave sides be the ground form of the upper division of the plinth of a column, whose plan is indicated by the inner circle,

and the circumscribed diagonal octagon by the ground form of the lower division of the plinth, then as shown in Fig. 475a, the transition by the pyramidal body b c d over the triangle abc, which makes the difference in the area of the two octagons, is found in Fig. 575, but in a richer way if a member formed according to the projection e f (Fig. 575b) rises from the edge of the lower octagon, whose angles pierce at the points g and h the concave surfaces of the upper mass of the plinth, so that instead of the pyramids mentioned, they form small moulded bodies. If then the lower octagon receives a greater projection, then would the moulding produced by it either join directly beneath this body, thus extending its moulding as in Fig. 575 r right, or by separated there by a short vertical piece.

It is not in the nature of such forms, that the ground forms placed on each other require each other, that further the plan so constructed also affects the dimensions of height in the elevation. Thus here the internal octagon first determines that circumscribed, and further the angle i of the square circumscribed about the internal octagon fixes the lower projection of the plinth. Thus in the elevation the height a b is fixed by the depth i k in the plan, the height c e by one side of the square described about the inner octagon, the height of the little pyramid or moulded body by the length a i in the plan, and in the right half the height f g is determined by a side of the inner octagon.

In the plan of Fig. 576a the proportion of the two inner octagons is then changed, so that the one set diagonally is described with the same length of sides as the first, instead of being circumscribed, so that the two octagons intersect each other. About both octagons are then described squares, yet so that the squares are set diagonally with the octagons and therefore intersect like the octagons and form a star plan by connecting the angles of these results the outer octagon giving the lowest ground form. Fig. 576 shows the corresponding development of the elevation. On account of clearness, the corresponding points in plan and elevation are indicated by the same letters.

Accordingly the intersection of the same ground forms of both octagons and of both squares, which has given the motive of the

form of plinth, and which in general afford an almost kaleidoscopic means of continually producing new forms. In Hoffstedt the term quadrature is assumed for the intersection of squares, and that of triangulature for that of triangles.

The development from the quadrature is expressed more decodedly, when both squares appear not at different heights as in Fig. 576, but in the same division in height. Accordingly is formed that of Figs. 577 and 578. The star ground form is expressed in the left half of the elevation by the prismatic body . b, c d, enclosing the octagonal nucleus, which at top forms the octagonal surface as at x in Fig. 575. These are set off by the plinth e f, so that also the members lying in the plane of this plinth project beyond its sides; by the lower member g is made the transition to the square. In a richer form the sides of the prismatic body can be still ornamented by blind tracery. In this manner is treated Fig. 578, which at the same t time differs from Fig. 577 in that from the star form the transition is not to the square but to the octagon, and indeed is not there only by a member, but is formed by a little prism inverted between the parts of the star.

Figs. 580 and 580a then exhibit a form of plinth from the t triangulature, which also has the peculiarity, that the members by which the triangular prism is attached to the hexagonal nucleus, not as before to the sides of the former, but here accompany the sides of the hexagon, thus intersecting the sides of each body at a b, etc. In the accessory Fig. 580b then the same treatment is applied to the lower offset.

The penetration of the octagon, which is given in plan in F Fig. 576a, then leads to an entirely peculiar development of the elevation, when especially as given in Fig. 582, one of t the octagons is placed below the upper, and the second is on the lower moulding of the plinth, when both intersect each o other for a short distance a b, and here produce the ground f form of the sixteen pointed star, where then the parts of star belonging to the lower octagon are attached by a wash to the surfaces of the upper one, and those of the latter by horizontal cuts to the surfales of the lower octagon. On the plinth of a round in the Liebfrauen church in Frankfort this motive is found to be expressed by the bands merely applied on the round nucleus of the plinth (Figs. 581, 581a).

To be able to compare the effect of this series of forms of plinths with the older simple forms, we also add in Fig. 579 a perspective view of such a later plinth. With all the animation peculiar to it by the alternation of light and shade produced by the entire arrangement, by its animated lines, it still remains far inferior to the quiet beauty of the older pronciple used as the basis for Figs. 558 to 565. It is even the lack of continuous horizontals or rather the loss by the animated forms of plan or by the weakened accenting that makes itself felt and that finally gives to the entire plinth the appearance of a crystal.

Therefore such forms can be given less to actual piers of v vaults, and then rather to those smaller posts for supporting a beam ceiling or to the bases of posts used for a corbelling. But first of all is the material wood, on which is indicated in a sense the impossibility of forming greater projections. However this treatment can only be obtained in the mass, where the principal parts of the old form of plinth at least are allowed to appear, when the different parts of the plan do not entirely abandon horizontals in the development of their elevatio

4. Vault Piers of Brickwork.

Their ground forms are the same as in stone construction, w with certain modifications due to the natura of the material, to the small influence of the separate pieces, and to the necessity of bonding. At first men yet adhered strictly to the forms of bricks, later was developed moulded bricks.

Thus it is first the sizes of bricks, which in the older works exceeded those now common (mostly 28 to 30 cm long by 8 to 10 cm high), which set a maximum for the shapes of the separate members of even the ground form of the rounds, and then the bond which indicated certain ground forms, allowing others only after overcoming certain difficulties.

Forms of plans.

From the direction of the end joints intersecting at right angles now first results the rectangular and the later cross or stepped forms of plan. The rectangular pier receives a richer treatment by constructing the corners with chamfered or moulded bricks, further by the projection of moulded parts from the sides, and also in a certain way by the arrangement of clusters of rounds. The bonding of these clustered rounds then

occurs in the same manner and also requires its treatment here. We have given this at the different sides of the square in different forms.

Fig. 584 then shows the plane of the pier in stepped form.The richness of such forms may be enhanced by complicated arrangement of the separate bricks. In the main plan it harmonizes w with the stepped plans occurring in stone construction, and is distinguished from that by the lack of detached rounds, for the yet small rounds can only serve as members at the angles, as such are also found on the piers of Rouen (Fig. 558), while the actual round is formed by the mass a b c d, which is therefore terminated by a rectangular capital, in which the separate members are collected together. The preference is peculiar to plans formed according to this priciple, that they directly result from the bonding, while all that cluster of rounds is in Fig. 583 left, which vary from the stepped form of plan, are only bonded by a departure from the ordinary arrangement of t the joints and require many different shapes of bricks.

Fig. 585 then shows only a bilateral symmetrical arrangement, when the parts beneath the dividing arches receive a form differing from those of the vaulting rounds. The last principle is most clearly expressed when in the entire plan the length exceeds the breadth or conversely, as in the Cross church in Breslau (Fig. 586), where the great width of the pier produced an extension of the pier in the direction of the length, and in the church at Bützow, where the converse condition occurs. (Fig. 587). Note.

Note. Essenwein. Brick architecture of north Germany.

A different shape can be obtained by setting the square pier diagonally (Fig. 588). The joints then run diagonally and the angles are chamfered, moulded or have projecting rounds. This form is to be mharacterized as especially happy, since it appears in suitable proportion to the members of the arches, but then brings out an elsewhere occurring practice of masons, whereby both in foundation masonry as well as in the treatment of projections a greater diversity is made in the entire direction of the joints by a diagonal position of the bricks. Here also the pier laid with diagonal joints stands beneath the cross arches and on the foundations, whose joints run in the directions of length and breadth. So an application of this sys-

system of the alternating courses then originates the octagonal plan. Fig. 589 shows the two courses lying on each other, each consisting of cross bond with the filling of the corners. Richer forms are also obtained for these ground forms by moulding the angles and rounds built in the surfaces. According to the same system of joints is then also constructed the round form. Yet here instead of the cross is also assumed the position of six rays, so that the diversity of the two courses in the same way, according as hexapartite division determines the direction of the rays starts from one or another point of the four sides. The round pier can also have attached rounds, but there is generally found the arrangement of four rounds.

Dividing arches.

The form of the dividing arches in their main forms are determined by the construction. According to their height they consist of two or more rowlock courses turned without bonding and concentric, their depth again decided by the width of a b brick, but must have a rectangular and more or less stepped cross section. The plan of a pier in Fig. 584 ma: therefore a also represent in the part a e f g h the profile of a dividing arch. Besides the separate forms of the bricks, this profile can also receive the desired diversities in form to obtain a different character, according to whether the lower rowlock c course has a width of more than one brick and as to whether t the size of the step is increased. By such arrangements will then be obtained wide surfaces in the height and width of the arch which may be plastered and painted, for the painting of certain parts and generally every kind of surface decoration is particularly suited to the nature of the brick construction. Consequently the dividing arch may assume another character if a rib brick is set in the lower surface, so that the entire profile ends below in an edge. The profiling of the rib bricks and forming the springing of the rib is already explained above, so that the general mass of the springing of the rib can be c constructed.

Forms of capitals:

With a pier formed according to the principles of Figs. 584 and 585, therefore is the springing of the arch in almost complete harmony, and a capital would only be necessary on the parts

designated by a b c d, in order to obtain the difference of this ground form from the springing of the rib, but only on the other part of the pier if the profile of the bricks of the arch differs from those of the pier. But the ground form of the capital will best follow that of the steps, so that the separate members either pass beneath the capital into the square or stop against its lower surface, while the arrangement of the different members enclosing the capital would already be ineffective by their small size. But the latter is entirely in place when the middle projection a b c d is replaced by a more united form, by several adjoining cylindrical rounds, which are then concentrically enclosed by the projection of the capital. In Figs. 583 and 585 is given the first arrangement of the capital at k and the latter at k'.

In all these ground forms of piers, which are based entirely or partly on the diagonal direction of the joints, like those of Figs. 588 and 589, they by the form of the capital must be extended the upper surface, so that it is in condition to receive the stepped form of the arch. For example that seen in Fig. 588 so that either by a simple projection extending around the entire ground form as given in the plan there, or in the capiral itself by the arrangement of one or more corbelled courses is formed the transition from the diagonal direction to the stepped one, or in other words, that the change of direction of joints occurs in the capital itself instead of between the capital and the springing of the arch. Fig. 588a exhibits such a treatment in a perspective view.

On an octagonal or round pier the ground form of the capital also follows that of the pier and also extends around any projecting rounds. But in all cases the projection of the springing of the arch as well as of the capital from the mass of the pier is very small.

The construction of the capital occurs in the simplest way by projecting courses of the ordinary height or that of a course set on edge, that has the required form of profile. (Figs. 590, 591, 591a). In all forms of capitals composed of straight lines, the pieces that form the corners must be specially shaped to avoid joints and cutting the bricks. Conversely the rounded joint is in place over the projecting angles. The jointing of the corner pieces is avoided if the mouldings generally

at one side (Fig. 590a, or the round passes through pieces of special form into the square (Fig. 590b). For the circular plan the separate bricks naturally must be formed as circular arcs, whereby the joints come to lie above the bisecting lines of the reentrant angles. Yet also here the round form is usually avoided and the capital is not a square, but with several intersecting rounds is formed of adjacent squares (Fig. 590a).

For a capital formed like Fig. 590 or 591, the part corresponding to the bell serves no structural purpose, does not result from the magnitude of the materials, and therefore is to be regarded merely as an ornamental band, as the bearer of rich decoration. Its ornamentation may then be made by painting or by relief ornament. The latter can be made of terra cotta or of mortar. In the first case the capitals of the rounds must be made as solid pieces if possible, and therefore can only be of small size. Since already the nature of the material allows no great relief and forbids all imitation of stone capitals, then the ornament must be chiefly effective by its outlines (Figs. 592, 592a). Certain leaves with sharply expressed outlines, scrolls or plants with simple or overlying leaves, are in place here. Fig. 592a shows such an example from the church of the monastery of Chorin. The ornament must be quite modest as a mere surface decoration. Facing with slabs of terra cotta has the disadvantage, that the proper surface of the pier is thereby reduced by the thickness of the slabs. Even if the slab itself aids in supporting, the manufacture of the slabs leads to frequent repetition and removes all its character.

More frequently are found capitals like ornamental forms in general of mortar with sharp sand. Whether cast like ashlars, or it is spread wet on the surface of the wall or pier and the ornament is modeled therein, as men executed works in stucco in former centuries, we cannot decide. Probably both methods came into use according to the size of the surface, so that only the smaller capitals, corbels etc., were cast, but the ornament on larger surfaces was modeled in the applied mass of mortar. The still remaining parts of the former Dominican monastery (the castle) in Lübeck have a great part of their richness devoted to such works. But it must be noted, for example that if the corbels are actually cast, it was still disdained to use repetitions of the same model.

Stone capitals on piers of brick masonry could be executed in the same manner as on stone, and they differ alone by the smaller size of the members or rounds, which they crown as well as the hollows in which their members enter. Therefore here is also in place all overloaded forms.

Forms of plinths.

Even more than for the capitals results for the plinths the condition of a certain simplicity. The forms in Figs. 558 to 565 are derived from the ground forms of cut stone and are only possible by their sixe. Therefore if it was ever possible to burn pieces of like size in clay, the proper nature of brick construction would thereby be denied, entirely aside from the impression of insecurity, which such a clay ashlar must produce. In the first place it is the work of the mason that gives its stamp to brick construction, and which only at the cost of the genuine effect of the whole can be supplanted by that of the stucco work or brick maker.

Accordingly the plinth remains in the ground form of the pier or round and only forms an enlargement thereof, which is then made of projecting courses of moulded bricks (Fig. 593). The richer members of the pier cannot therefore be expressed in the plinth, and they recede over the plinth in one or more adjacent squares, that extend around the projection of the plinth, or they also remain without a base and rest on the common plinth of the pier (Figs. 593b, 593c), then extend so that the bricks forming them must be cut according to the sections of the vertical parts. Thus the rounds built in the angles or surfaces of the octagonal piers generally extend to the plinth of the octagon. But the cutting of bricks cannot be entirely avoided, where cutting becomes possible. It is a procedure required by the nature of brick construction, without which even with the most extreme use of moulded bricks cannot be executed a vault, and must then appear consistent, i.e., where applied to parts coming under the eye, if the mason's work is not done by the day and sinnks to mere slave labor. For even then the work of the mechanic is distinguished from that of the day laborers and manufacturers, because it will be seen and the stamp of its goodness or badness cannot be denied.

5. Ceiling Columns and Detached Posts.

Stone columns for ceilings.

Stone piers that remain in small number, which could serve for supporting wooden beams and girders, as under the organ galleries of small churches, beneath the roofs of vestibules (on so-called verandahs), or in halls of considerable width, differ substantially from piers of vaults.

Basal form of shaft.

What first concerns the ground form of the body proper or shaft is that such is chiefly simple as a square with chamfered angles, or formed as a polygon or circle. A form of pier requiring subdivision into actual rounds could indeed be indicated by certain ceiling constructions, yet according to the conditions of the affair might either become puerile or require an excessive expense in size and space.

On the contrary according to the fluting of Greek columns, there is formed a subdivision of that simple ground form in a way, that it returns to the ground form above the plinth and below the capital.

The ornamental character of such a treatment is also then expressed, in that these mouldings, particularly according to the later mode of treatment, are seldom er vertical than made in spirals, and also intersect spirals in the contrary direction or verticals, and thus approximate the character of a surface decoration.

A basal difference of such stone parts from vault piers is, that the former could not be conceived without a capital, since it brings the material of the shaft to a termination, therefore assuming an entirely detached position of the supported parts.

Ground form of the capital.

The basal form of the capital is square in the simplest cases. Variations from this will be determined by the construction of the beam ceiling in the same manner, as the piers of vaults by the plan of the springing of the arches.

According to the usual arrangement the post bears a girder on which lie the ceiling beams, just as the Greek column did the architrave on which rested the stone beams. Accordingly the lengthwise direction of the girder must be expressed in the form of the capital. This relation is not indicated on the capital of the Doric column, the ground form of the capital b being entirely concentric, so that the changed condition of the

angle column on which lies the architrave in a twofold direction is not expressed, or rather the form of the intermediate columns of every colonnade seem imitated from that of the corner column. A higher organism animates the Ionic capital. Here the longitudinal direction of the architrave is expressed in the movement of the volutes accompanying it, and a meeting of those coming frog both sides in the corner column permits its projection diagonally, so that its peculiar position and the character of the entire combination is repeesented in the most beautiful way.

It even harmonizes with this relation of the form of capital to the direction of the architrave, that according to a later transformation the Ionic capital received four such angle volutes projecting diagonally, if as generally occurred the stone beams at the height of the architaave had a size and form equal to that, thus finding their bearings on the column, and so each returned in the Greek arrangement to the conditions of the corner column.

Therefore in all this is seen indeed a refined and spirited indication of the structural conditions, but an aid produced by the construction, for the area of the capital remains in all cases an exact or approximate square, both affording the same bearing on the corner column with the meeting architraves as when it simply extended over them.

An improvement in the bearing, a transformation of the ground form of the capital corresponding thereto, on the contrary is found on ancient Indian forms of capitals combined with corbels. Gothic art that brings actual aid for every need, and only indicates what satisfies the condition, must also therefore in t this case pass to such a change of the ground form of the capital, that the free length of the girder is reduced thereby, so that the possibility of a wide spacing of the supports is afforded, and likewise a suitable bearing for girders crossing in the same plane, i.e., the ground form of the capital becomes a rectangle under a simple girder, or a cross beneath two that intersect, or meet by a T beneath two that abut. Variations therefore by retaining a simple concentric ground form indeed are frequently found. But then the post is either connected with other structural parts, like wooden caps, etc., or it ser-

serves exclusively to support a beam ceiling, or rather it first supports points especially loaded and near together, so that the required closer spacing reduces the free length of the beams so much, that this aid becomes superfluous.

Elevation of the capital.

The means of obtaining the ground form mentioned, thus first for the transition from the concentric form of the shaft to the rectangular, consists in the connection of the capital with two or more forms of corbels, by which both parts receive a more separated expression, or the body of the capital passes directly into the corbel form. The separation of both parts occurs most distinctly in those Romanesque capitals recalling a similar purpose, whose tops received a corbelled shape. But such a form is less suited to the ground principles of Gothic art, which requires two pieces lying on each other, and therefore instead of placing both parts on each other, their junction occurs in one block.

A very beautiful example of a capital with side corbels is found in the Dictionary of Architecture by Viollet-le-Duc. Here the body of the column extends above the astragal, expands with a slight bending of the edge of the bell to receive an octagonal abacus for the ceiling members, and is carried around corbels at both sides, penetrating the body of the capital. The part of the bell remaining between the two corbels is then covered by a bunch of leaves laid thereon, and on the fronts of the corbels are placed shields of arms cut in the mass of the stone. The upper surface is therefore of the form indicated in Fig. 594. The purpose of the projections indicated by a b c d and e f g h will be explained below.

To obtain a bearing for a single beam sufficed a simple rectangular form, or for the corner two such intersecting at the angle of the corner, for example is shoun in Fig. 595a. The elevation can take the form given in Fig. 595, which may also be employed for the capital formed as a simple rectangle. the form could be simplified by omitting the foliage and the bent edge of the bell, whereby the member a could penetrate the cylindrical or prismatic body of the capital, and finally by a breadth of the corbel equal to that of the diameter of the column, whereby it projects from the middle of the column on both sides, and the body of the latter must penetrate beneath the projecting

moulding. An example of the latter is shown by Fig. 596.

In the same manner as Fig. 597 shows, the side projections would have leaf-like supports. Figs 597a and 597b show the plan and elevation of such a form.

The parts hatched in the plan indicate the origin of the corbels a projecting at both sides (Fig. 597b), whose upper edge extends beyond its lower surface and is supported by the part a b c of the beam indicated on the plan. Over this corbel and thus at b on the elevation then appears the vertical face indicated at d, which has penetrated the part of the bell developed on the part e f of the plan. The entire form lies on t the rectangle by the slab q projecting over the upper moulding.

Likewise with the projection at one side is also the form of capital according to Fig. 598 connected with two concentric c corbels, and thus is obtained the oblong surface, whose relative length is removed farther from that of the post.

Also by a junction with moulded corbels would be produced a proportional length of the upper slab, if the mouldings penetrate the body of the capital horizontally in the manner explained on p. 244 (Figs. 599, 599a).

The means for obtaining the different forms further result from joining the concentric capital of the column with heads or other figure forms, that support the desired projections.

Directly by the form of the capital is further obtained any form of the upper surface, whereby the projections of the body of the capital wary toward the different sides, and the surfaces enclosing them became partly oblique. Such an example is shown by Fig. 600.

Further the upper area obtained by a concentric projecting capital can be made oblong by cutting from the body of the capital. Thus in Fig. 601a from the octagon a b c d e of the projecting body of the capital is cut vertically the part designated by the triangle b c d, so that the surface a b d e remains, on which rests a rectangular moulded slab. By that cut are also produced on the mass of the capital at both sides the vertical surface f in the elevation of Fig. 601 in the same manner as the semicircular surfaces on the Romanesque cushion capital by cuts from the sphere. Fig. 601b shows the corresponding side elevation.

The same procedure may then be applied to any other polygon,

to the octagon parallel to the direction of the beam, the hexagon, decagon, dodecagon, etc., and to those forms set diagonally. Fig. 602 shows the form of the duodecagon set diagonally, and Fig. 603 that from the diagonal square in perspective view. In the latter are retained the angles of the square falling under the beam, so that the transition from the moulding to the square beam must be forbed thereby. But just as well could the upper ground form have been changed into the rectangle according to either Fig. 601 or Fig. 602.

Placing the beam.

The beam or girder lies on the abacus of the capital and is held in place by a pin. The latter can be omitted if a so-called groin is cut in the top of the abacus as shown by the cross section in Fig. 599, in which the beam lies. Instead of cutting the gain a b c d for the entire length of the slab, it can consist of two shorter gains, so that the capital has a cross shape and two cross arms extend the bearing of the beam, and two others serve as sides to support the beam, and thus the capital assumes the form given in Fig. 604. If such an arrangement is employed in the open air, it will be necessary to cut a little groove behind the projections, which will remove the rainwater entering the joint between the wood and stone, and the most varied shapes may be obtained by the form of these openings. These may be developed into formal strongly projecting parts, t that if permitted by the distance of the posts allow it, could even support gutters laid thereon, that have to receive the w water from an upper roof (Fig. 605).

The ground form of the cross is further indicated also for the upper surface, where the post stands under the crossing of two beams or girders. Such cases may be required by certain departures from the construction of ceilings now usual, and to be mentioned later. A simple example of a corresponding form is found in the court of the hospital of Beaune (Note), where the cross form of the capital had but three arms. The fourth was added when the end of the beam on the post had to bear the post of the upper story and thus the corbel supported it.

Note. Arch. civ. et dom. Viollet-le-Duc. Dict. Arch. p.543.

If the upper story is then to be composed likewise of stone piers, then must the nucleus of the lower pier continue while

the girder only rests on the projections of the capital, so that there results the form of Fig. 594 in plan.

What now concerns the relation of the size of the post to that of the girder, in the simplest case the latter may have the width of the capital, and the column only be less by the always slight projection of the capital. Yet to prevent the breaking of the upper horizontal edges of the capital by the load of the girder, this may be surrounded by a moulding projecting beyond the breadth of the girder as in Fig. 603, and thus at the same time receive a more complete ending. The moulding then terminates at top with a wash or a rounding. This increase in the width of the capital further becomes necessary by the use of a gain given in Figs. 599 and 604. The theckness of its sides can be obtained by either the general form of the capital or by the projection of the upper moulding, on which the wash is replaced by a vertical fillet.

To the forms of the plinths of such piers applies what has already been said above relating to the plinths of piers.

Wooden posts.

Far more commonly were wooden posts employed than stone piers. Actually certain advantages are peculiar to them by the ease of connecting with the beam or girder supported and the convenience of placing. Under existing conditions, where the wood must be wrought too green, this brings the disadvantage, that it cracks easily, and therefore makes necessary the most varied means of filling these cracks.

From the use of solid logs results the ground form of the octagon, and that of the square from the hewn timber. Since it is of importance to leave as large as possible the bearing surface as well as that by which the post rests on the foundation, then the ground form must be the top and bottom surfaces, and hence the posts variously reduced in their length must return to their full shape below the girder and above the plinth (Fig. 606). Since the entire height of the post is a single piece, therefore the reductions or the projections of the mouldings thereon cannot be very great.

Entirely nonsensical is aiding the lacking projections by nailing on fillets. Such expedients are comparable to those f false locks of hair still in the thirties forming a necessary part of female full dress, and indeed are so far beneath the

works of the hairdresser mentioned, since the latter were at least on a proper place, and not quite capriciously attached, as it sometimes happens with the mouldings concerned. Not the nailing is perverse, but the unfortunate intention to deceive. Thus the actual ornamental parts like shields of arms, etc., in which is innate no structural importance can be attached in other materials, but then so that they are recognized as accessories, standing free or placed over a joint.

Polygonal parts.

Thus bilateral projections on the capitals of stone piers cannot be formed in the body of the wooden post, but must be made of pieces otherwise attached, that accordingly aid in forming the capital of the post. Also the post generally stands on a stone plinth, that may then receive a projection of the required form and have its own shape (Fig. 606), which represents the simplest form of a post of polygonal shape. Then the oblique surface that makes the offsets at a and b may be replaced in a richer way by mouldings, that either extend in straight lines, or from the middle of the sides rise or fall in straight lines or curves (Fig. 607), and further by forms like capitals (Fig. 608), which can again be ornamented by foliage and offsets in the ground form, of which Fig. 609 gives a simple example, while richer ones may easily be developed according to what was said above.

In designing it is first to economize the projections and further to give the preference to those forms best suited to the material, which can be made by simple cuts, avoiding as far as possible cutting against the grain. Further the manual working of all such details that with the variously shaped chisels and gouges are done freehand are to be considered in the design, so far as they lead to the arrangement of curved surfaces, in contrast to that done in stone with the mallet and chisel, where the stroke first produces a plane surface. It is further to be considered that of all parts of the post the proper body or shaft must have the smallest diameter, also that no moulding may be cut in its surface as wrongly shown in Fig. 610, since otherwise is formed a weak place favoring breakage, that would be particularly defective at mid-height.

Richer forms are produced by the arrangement of certain capitals or rings remaining in the mass of the shaft. For the

capital results a function by the arrangement of the head braces resting on a projection and fastening in the post by tenons, making unnecessary any further projection (Fig. 611). If as caused by ordinary conditions the head braces occur in only one direction, then between them the upper end of the capital may have a different treatment, in the simplest case ending above with a wash or moulding. Instead of this capital surrounding the entire shaft, there may also remain beneath the head braces only their supports in the mass of the shaft (Figs. 617,617a)

Further at the middle of the post or otherwise arranged distances may remain moulded or ornamented rings, whose importance is mostly ornamental, and only consists in this, that the shaft gives the projection, and thus the form of the post is represented as in one piece, see g in Fig. 611.

Square posts.

The same forms are repeated on the carved wooden posts of s square shape, except that here a new motive of form arises from the need of chamfering. The chamfer may either be simple or moulded, or result by a change to the polygon. The change in the rectangular corner may either occur at the capital and plinth (Figs. 612, 612a), or be made below and above them. There is also sometimes found the mode of treatment given in Fig. 613 producing a very peculiar effect, whereby the chamfers instead of returning to the ground form below and above the mouldings of the capital, extend through both and only change beyond them.

Mode of treatment.

Richer forms result by combinations of mouldings and capitals with ornamental bands of tracery on the foliage, yet may also be more simply obtained by chamfer cuts (see g in Fig. 611), and further by decorating the surfaces remaining above the capitals. The ornament may either be sunk in those surfaces, or be made better by disks applied on them, shields of arms, bands of inscriptions, heads, leaves or tracery, or by those latter substitute forms, which consist of interlaced arches or figures in straight lines (Fig. 614).

Likewise also the side surfaces of the posts may be ornamented for their entire height by branches laid on them, by sunken panels enclosing tracery, or in the mode of the late Gothic by scrolls and by combinations of the latter forming richer

patterns. Retaining the diminution that resulted in very slight degree from the original form of the trunk is found only on late examples, thus among these are the raised galleries usually built in the older churches during the course of the 16 th century, whose posts retained their original character until the middle of the 17 th century. According to the same principles as for these posts are also formed those little columns of galleries, clocks, etc., for which modern art has introduced the turned baluster, which last forms the stair railings in ordinary structures, and were sold by the piec like hobnails.

As generally the peculiarities of work in wood indicates a more ornamental treatment of the various parts, thus finally certain originally structural forms of stone construction are used as decorative motives and are characterized like the wooden piece. Thus flat finials or gabled forms lie on one or more surfaces of the posts as in Fig. 615, which still utilize diminution in the treatment, and there can be made in such wise direct imitations of the richest stone architecture, when the forms of piers and of finials with their complete basal forms lie on the sides of posts and are carved in an excess of the size of the timber. These can then rest on the stone plinth or be corbelled out from the surfaces, but above be connected with certain cornice or gable forms likewise projecting before the plane of the girder or other connecting parts, thus forming an ornamental architecture overlying the proper construction, but producing thereby an extremely rich effect. Such certainly belong to the latest period in their detail forms in the decoration and are also found on wall parts, and indeed are especially common in the cities of Normandy.

But even the antique caryatids came into use in wooden construction. Thus are found free posts under a vestibule of the city hall in Treffurt, that represent human figures and are in elongated form with refeeence to the proportions of the post, and to avoid all excessive weakening are very compactly treated. The effect produced is certainly very original, more that of a good jest. Gothic art like life likes to mix such with seriousness. But nothing is more foreign to it than the cothurnus, which stumbles over every humorous circumstance. The humor of Gothic architecture is not opposed to an intended jest, which elsewhere springs from the predominantly tragic character of

the various modern Byzantine or Romanesque art figures.

The posts are either flush with the girder or project beyond it on both sides. In the first case they are tenoned into it, in the second the girder lies in a fork. With a polygonal shape (Fig. 611) this is formed by the parts a b c d in Fig. 611a. Yet as a rule the angles a and d are chamfered as given at f. If a cap is also placed beneath a girder the profile of this cap can be formed as in Fig. 611b, and the cap whose width projects beyond d e can be notched and then its reduced breadth also rests on the sides of the fork. In Fig. 611b b denotes the cap, whose full width is indicated by the dotted lines, and n is the girder.

Brackets and head braces.

Both the girder and the cap are supported by the post by means of brackets or top corbels, by which connected parts the proper projection of the post is produced. The brackets either have the width of the girder or less, and are either fixed in the girder and post by tenons and boxing, or are placed directly in the right angle between them and are spiked to the post, or are tenoned only into the girder. In the first case the triangle a b c in Fig. 616 is the basal form from which results a flat curve as the proper outline, at the middle of which is g generally inserted a moulding crosswise (Fig. 616), a form like the nose or a more or less decorated disk remains in order to avoid excessive weakening of the wood. From the wood to be removed in forming the curve is then sometimes formed a plant ornament or an animal form that lies on the background.

Likewise the timber at the junction of girder and post may be strengthened by a moulding (Fig. 617), which sometimes extends over the entire surfaceof the bracket (Fig. 618). Usually then certain parts are cut from the sides, either by completion of their ground form, when the enclosing circle is struck about the round (Fig. 616) or so that an entire part of the moulding in smaller width seems inserted in a hollow extending the entire width (Fig. 619). Rounds further are sometimes ornamented by flutes, waves or vertical incisions, the hollows by rosettes or disks. Also there are found frequently carved on the side surfaces rosettes, shields of arms, circles decorated by tracery.

When the brackets are spiked to the post, their profile must be such that the nail requires no excessive length, and it must

therefore agree with the post in distance and direction for a short space, while it extends below the nail (Figs. 620, 621). On brackets of this kind the direction of the fibres of the wood is generally vertical.

Head braces.

Head braces are boxed and tenoned into the girder and post, or indeed abut against them. Fig. 611 shows at h how the boxing is replaced by the arrangement of the capital. They are described in many places, thus on the butchers' stalls at Frankfort, in the monastery buildings at Haina and Eberbach, the arrangement is that the octagon exceeds the width of the head braces. If the latter are greater, the post must return to the original form to receive the braces.

The head braces will either be made of curved pieces or of straight wood. In the first the curves are prescribed for both sides and may receive a richer form either by a chamfer or cove on the angles. In the last case the backs retain the straight form, while to the lower line or true profile all applies that has been said of brackets. Yet the greater length of the arch causes that a decoration extending over the entire front as in Fig. 618 appears least suitable, and the form in a curve, whereby the middle of the brace has a projection as mentioned for brackets, (Note), or a compound arch line predominates. Likewise the brace may remain straight, and its underside be moulded with a return to the square at the junction with the girder and post. Generally those forms are most suitable by which the length of the brace are accented, while all mouldings cut across it require certain depth for the heaped arrangement to remain effective, and then they weaken the wood so much as to lend to the whole an unsafe appearance.

Note. In Verdier add in the Dictionary of architecture by Viollet-le-Duc are found examples, where these additions in t the form of dragons complete the proper body of the brace, so that the arch line almost touches the straight back.

Particularly unfortunately appear the forms so favored in modern wooden architecture, whose principal element consists of the curved modillion like the antique represented in Fig. 695, which is either used singly or doubled, or is separated by intermediate members. There are here criticized also other

common procedures in modern architecture, by which elements of the most different styles are employed in a sense entirely different from the original one, with the secret idea of contributing to the hoped for new style of architecture. Thus the effect of these consoles which so frequently form the brackets in the wooden buildings of the 16 th and 17 th centuries, as well as the ox eyes, pearl beads and other parts like the antique are especially rich, since they are used in their original or slightly modified forms of a means of decoration.

Wooden caps.

The head braces are usually connected with a wooden cap. Their combination is most clearly expressed by this, that their curves sometimes continue over the cap, and the boxing is radial (Fig. 622). By the treatment of the ends of the cap may t the simple curve pass into an ogee or compound curve. The latter sometimes becomes a second beam extending between the posts with a smaller width than the upper one and tenoned into both posts. In this case the curve of both braces can be continued over this second beam so that at the middle it joins a semicircle, pointed arch or a curve, and the crown of the curve is cut in the girder. The wooden parts to be wrought here, as for the corbels, may employ any moulding or other form, and thus reduce the weakening of the timber. (Fig. 623).

6. Corbels, Cantilevers and Corbellings.

General and statical.

No difference exists in the nature of consoles and corbels. By the former word is denoted the relation of the corresponding cut stone to the wall or pier with which it is bonded, and by the latter its purpose in general. The uncertainty thus arising appears to have occurred by the term "console" so favored in Germany.

Purpose of classification.

According to the form can be distinguished central and one-sided corbels, the first takink its development from a point and usually its upper plan forms a part of a polygon, the one-sided corbel on the contrary having a rectangular plan.

The problem assigned to the corbel may have a manifold nature, it can offer a bearing for a stone lintel or wooden beam, may receive members of vaults or rounds, and finally may be destined to bear statues, etc. Especially manifold is its use

for the springings of vaults. Already en the Romanesque period very freqently occur corbellings in churches and still more freqently in conasteries and secular buildings instead of rounds extending downward, and which either by a short round (Figs. 665, 666) or deriectly, receive the springings of the vaults (Figs. 654, to 658). That on the one hand is not to be employed statically the omission of the lower part of the round as separate from the wall shaft, was alreadn stated above (Abutment), p. 126 and Fig. 343). The thrust of the vault usually passes obliqely into the wall a considerable distance a above the ground line of the arch. The capital of a little shaft or projecting corbel is commonly not affected by the thrust of the vault, so that these members rather fulfil an architectural than a static function. On the contrary the stress in the corbel under beams, girders, etc., is sufficiently important to reqire a closer investigation.

Stress in the corbel.

Statically considered, there are three possibilities, the bonded corbel (Fig. 624) under the load may rotate about the lower point d, and can also be sheared on the surface a d, and finally it can me broken.

1. Safety against rotation. The load Q tends to rotate the stone about the edge d, and on the contrary it is prevented from rotation by the weight G of the masonry resting on the bonded portion a c e d. That the stone may be safe there must be G n greater than Q m. Accordingly a great weight of masonry and a longer lever arm a c of the stone are useful. From safety in calculation the point of rotation d is not taken at the face of the wall, but a few cm farther back toward d′. Good bedding of the stone at this place is of the greatest importance, and also the upper bed a c must have corresponding consideration. If the danger of rotation is great, then with good donding above the stone there must be placed as large a part of the masonry as possible to load it. If it can be assumed that the entire thickness of the upper wall acts as a united mass, then can be made the adjacent calculation, which presents a favorable result (Fig. 625).

The corbel tends to rotate the wall about the point f with the upward force K. To prevent this we must have G r greater than K u.

But now $K t = Q m$ or $K = \frac{Q m}{t}$ and substituting this value; $G r$ is greater than $\frac{Q m u}{t}$, or $\frac{G r t}{u}$ is greater than $Q m$.

2. Safety against shearing. Shearing or separation of the stone comes in question, if the load Q (Fig. 624) lies close to the wall. The shearing stress is very simply found by dividing the load Q (in kil) by the shearing area a d (in q cm). the stress thus obtained per q cm must not exceed the permissible limit that is very low for stone. Assuming the usual safety, there must be allowed only 1.5 to 4 kil per q cm according to the nature of the sandstone or bricks, 3 to 6 kil for limestone and 5 to 10 kil per q cm for granite.

Example. The cross section of a cantilever in the face of t the wall is to be determined in its required area, if it must support a load of 4500 kil, and it is made of good sandstone with a safe limit for shearing of 3 kil per q cm. According to the preceding the cross section is very simply calculated at $\frac{4500}{3} = 1500$ q cm, so that the stone may be made 30 cm wide a and 50 cm deep.

If a corbel has a very slender frofile at is not to be forgotten, that the shearing may follow a shorter depth i k (Fig.626

3. Safety against breaking. (By bending strass). Breaking by bending stress easily occurs, since the tensile resistance of most stones is less than their resistance to shear. If both are equal, then already by the lever arm of the load Q of more than 1/6 the depth of the stone, breaking will occur more easily t than shearing.

a calculation can be made by the well known formula, $W = M s$. In this M = bending moment (in Fig. 624 = Q m).

S = allowable tensile stress, that according to the nature of the material may be taken at 1 to 10 kil per k cm.

W = moment of resistance of the area of cross section bonded in the wall (for a rectangle = $\frac{b h^2}{6}$; for a triangle = $\frac{b h^2}{12}$).

Evidently no cracked stone, but only a good material resisting tension should be chosen for important corbels.

As a handy rule it may be assumed, that a corbel of moderately good material, whose projection does not exceed its height in the plane of the wall must have a cross section (at least) containing as many q cm as the load on it is in kil.

For a profile of the corbel shaped as in Fig. 626, there is naturally a fracture again to be feared at the shorter line i k.

If the stone is correctly shaped statically, then between the wall and the extreme end is to be found any section at which the stone can break more easily than at the wall. But according as a contentrated or uniform load exists, at least the triangular profile of Fig. 627 or the convex one of Fig. 628 is required. Instead of the triangle is rather recommended the trapezoid indicated by the dotted lines with regard to shocks at the end, defects in the stone and fracture surfaces extending obliquely. The basal form of Figs. 627 or 628 may be enlarged in any way, but cutting into these outlines is dangerous.

Proportion of heights.

On the ratio between the projection and the height no statement can be made according to the preceding; the greater the load the higher must be the corbel. That the springings of vaults are sometimes found supported by lower corbels comes f from the fact before stated, that the entire springing assumes the function of the corbel. For cross arches of wide span the corbelling certainly assumes this function and rekuires a correspondingly greater depth.

The ratio between projection and height mostly lies between $\frac{1}{1}$ and $\frac{1}{2}$, but even exceeds the latter. If a geometrical ratio is sought, then the height may correspond to that of the diagonal of a square constructed on the projection or to the diagonal of a cube constructed thereon.

Central corbels.

The simplest form of a central corbel is one half an inverted cone or pyramid (Fig. 629), which may pass by curvature of the sides into the forms of Figs. 630 and 631. By combining two s such forms is produced a compound corbel like that of Fig. 632.

Capital and corbel.

The most common function of the central corbel is to form a substitute for the round, also to support the springing of the arch, and accordingly its top corresponds to that of the capital of the round. This agreement that the function of the round is most clearly expressed, if the corbel takes the form of the capital of a round, whose lower circular surface is then occupied by an ornamental form, even to remove the character of a bearing surface as in Fig. 633 from the church of Haina and F Fig. 635 from the foundation church in Wetzlar, in the latter being made the transition to the square. The change of the lower

bearing area must be regarded thus as the motive distinguishing the form of the corbel from that of the capital.

Between the capital and the perfected corbel are to be mentioned various intermediate steps, one being represented in a slightly later nave of the church in Haina, on which the leaves placed in part on the edge of the lower capital extend in the sides of the capital, partly bending downward around it, concealing the astragal or replacing it by their own bodies, and so covering the lower horizontal surface. The plane area of t the latter is further lost in the mass, when the ornament receives a stronger modeling, but very decided in the example in Fig. 636 taken from the church in Volksmassen, where the astragal and the rosette covering the bottom of the capital have taken the inclined position.

If according to the form shown in Fig. 634 the difference b between the sides and underside at least disappears in the treatment, it is still more the case if the astragal is replaced by a branch extending around the lower edge or a plait, from which the leaves ascend at both sides. But all that agreement with the form of the capital vanishes when from the lower end the foliage extends up over the entire corbel. The nucleus of the corbel covered by foliage must then also experience the corresponding change, and first its lower edge is rounded as Fig. 637 showsin an example taken from the Preaching church in Erfurt. On simpler forms is omitted also then the outward bending of the upper edge, and thus all recalling of the bell shape of the capital (Fig. 639). The form of the nucleus is either concealed by the leaves lying thereon as in Fig. 638, or in very visible distinction between them is in Fig. 639 from the late Gothic cloister of the foundation church in Fritzlar.

Simply subdivided corbels.

An entirely similar transition is made from the capital form by a reduction of the lower bearing surface, thus by a change in the line of projection of the capital as shown by Fig. 640. According to the same principle are shaped Figs. 641 and 642, the former from the vestibule of the foundation church in Fritzlar and the latter from the nave of the church in Haina. Thus is followed a stage from the capital to the simple corbel. The latter can also exhibit the profiles of Figs. 643 and 644 besides the forms given in Figs. 629 to 631. By chamfering the

angles results the simple but corresponding form of Fig. 645. By varied profiling can forms originate like those of Fig.646 to 653 in section or elevation.

Compound corbels.

Corbel forms of greater height are generally obtained by a combination of two or more plainly distinct parts as indicated in Fig. 632.

The simplest case is a body like a capital in the upper part, supported by a simple form of corbel below, as in Fig. 657 from the cloister of the cathedral at Riga.

The character of the whole changes according as the capital or the lower corbel predominates. In the first case the latter becomes a mere ending without essentially increasing the strength, and forms a continuation of the moulding of the astragal as in Figs. 658 and 635; in the latter the proper corbel generally is a projection at one side for obtaining a more rectangular surface, from which the capital thereon makes it central. Such examples are shown by Fig. 656 from the rood scraan of t the foundation church at Oberwessel and Figs. 654 and 655 from the north side aisle of the monastery church in Haina.

The latter bear the rounds starting above the sills of the upper row of windows, and are of special interest for the beauty of their treatment, of which the small scale of our Fig. o only allows an imperfect conception. To it by its location in the height of the mouldings extending beneath the window sill is added an originality, to which we cannot refuse our attention. Instead of carrying this cornice around the corbel as a terminating moulding, as would have been done in the sense of modern architecture, thus serving different purposes in the same form, it extends into the capital of the projection, whose leaves bend over the edge of the moulding in an extremely graceful way, while the abacus thereby recedes above the cornice in question and intersects its wash, so that the base of the round rests on it entirely free (Fig. 655).

The body inclosed in leaves in Fig. 654 can serve just as w well as a cornice extending around as a capital. Generally the form of such a cornice decorated by foliage is so nearly allied to that of the body of the capital, that the former may be regarded as a low capital, as shown by comparison with Fig. 658 to Fig. 659.

Development of the corbel.

Forms of figures like animals, heads, etc., come into use in various ways. As in Fig. 654 they may sit before the body of the projection, or as in Fig. 656 be employed at smaller scale, may form only the termination of the corbel. Figs. 660 aod 661 show examples of the last kind from the church in Frankenberg. Further and especially heads may also furnish the corbel without a capital resting thereon, then being surrounded by either an edge moulding, a flower in front, etc., those not terminated above or even lacking such a margin, end horizontally and bear the rib on its upper surface, or as a head with foliage growing from it form the corbel. Likewise may it rest on the body as a mere ornament, either in connection with foliage or without it.

That an importance must lie at the ground of such forms has already been noted above. In corbels serving to support statuue this is given by its relation to the figure. In the same sense may also be employed bends with inscriptions, shields of arms (Fig. 653), where the location and outline of the shield are given by dotted lines.

The possible arrangement of bands with inscriptions and legends on the corbel indicating the importance of the figure well aids understanding them in the old works. In modern times the characteristics of the figure itself makes this explanation unnecessary, but in cases not too rare are given a riddle.

The arrangement of statues on corbels is sometimes found connected with the springing of the rib in such wise that the latter rests on the canopy over the figure, as in the church of the castle of Marienberg and at the cathedral of Minden. Thereby the springing of the rib continues vertically before the eye and replaces the effect of the round.

Also to support in Fig. 658 the surfaces of the lower moulded part below the astragal a b against the wall, this arrangement for connecting the form of the corbel with different ground forms combined, so that the projecting parts of the upper body are supported by the sides of the lower, thus imitated as on late Gothic plinths of piers.

The lower ends of the corbels are sometimes concealed by bunches of leaves or branches from which then rises the bell shaped body, or such branches lie directly below the springing of the

rib and replace the corbel. Such an example is shown by Fig. 632 from the cloister of the collegiate church in Fritzlar.

We have already shown above by Fig. 278 how by a limited area of the capital under the springing of the arch, the corbelling of separate arches or certain parts of them could be arranged. Such a very graceful example is shown by Fig. 663 from the choir of the church in Volksmarsen. Fig. 663a represents the profile of the rib, of which only the part a b c d finds a bearing on the capital. From the surface b c then first projects the member b e c, so that the rib takes the form a b e c d, from which by the upper corbelling shown in elevation it passes into its actual cross section a f g h d.

In Fig. 282 we have given the springing of a rib resting on three corbels combined, taken from the Erfurt cloister. But sometimes certain irregularities in arrangement and the need for recovering lost planes on greater and more effective forms of this kind lead to a combination of different kinds of corbelling. For example as shown in Fig. 664 by the springing of an arch in the northwest corner of the church at Wetter.

Gorbel with a short round.

As in Figs. 654 to 657 a greater size of corbel is obtained by placing a capital on the corbel proper, so that the magnitude of the whole is also increased if a portion of the round or wall pier replaced by the insertion of the corbel.

Fig. 665 shows the corbelled wall round in the choir of the Minorites' church at Höxter, while Fig. 666 represents the support of the cross arch recurring in nearly all churches of Reval, and it shows there like an architectural member a dry simplicity compelled by the hardness of the stone employed.

Richer forms of this kind are found on the western wall of S. S. Maria's church at Mühlhausen below the springing of the dividing arches. These start from the upper octagon, that corresponds about to the size of the springing of the arch, each being formed of five sides of the octagon, crowned my a part of the pier with a foliage capital, so that the projection from one to the other and from the upper to the octagon including the basal form of the springing of the arch are effected by capitals, below which on the bodies of the two upper piers are found on each side surface two slightly projecting round arches with cusps, while the side surfaces of the lower part of the

pier are decorated by tracery. The capitals thereby receive a greater projection in front than at the sides, so that the ground form of the part of the pier remains everywhere bounded by the five sides of the octagon.

By the use of what has been described can be developed an endless variety of forms. Fig. 667 may serve as a further example, that contains a motive reappearing in all periods of Gothic art.

Strongly projecting corbels.

Only when the corbel has the form of a semicircle or half p polygon will its lower plan be geometrically similar to the upper one; if the upper area exceedr half the ground form, then will the lower do this in a still higher degree, and finally be the entire form, which is free before the wall or the surface of the pier. Thus the upper area in Fig. 654 is formed by a part of a circle comprising about 225°, and thereby the lower part is nearly the entire circle, that must be entirely separated from the face of the wall by a considerable projection of the bell as in Fig. 641.

Still more decidedly appears this condition in corbels projecting from a point as shown in Figs. 668 and 667. As shown in the first Fig. ec the side view, the corbel would terminate in a point hanging free before the face of the wall, and thus its lower portion is undercut (also see Fig. 665). If such projecting knobs already produce a specially bold effect, then is still thereby lost a part of the height if the ashlar for the s support in a useless way. But these free hanging points may be avoided, if only in the front half the projection appears concentric from the middle line, and conversely as in Fig. 668 t the rear undercut is omitted, so that the moulding penetrates the face of the wall in a direction parallel to the projection. Thereby the point below is changed into a horizontal edge or a rounding.

Another means of transition results from the oblique development of the corbel when the lower part is placed in the face of the wall, while the middle of the upper part projects from it. When this solution is applied to a simple corbel which accordingly projects from a point lying in the face of the wall to an upper surface formed of five sides of the octagon or four of the hexagon, then the sides become oblique. Such forms are

then employed for both simple corbels as well as those covered by foliage, but in the last case they would be concealed by the leaves lying before them. Examples of this kind are shown by Fig. 655 from the church at Haina and Fig. 669. Here also belongs the arrangement particularly common in the 15 th century, whereby the corbel imitates a little column with a capital, w whose shaft forms the actual projection instead of remaining vertical, also with an arch that sometimes leaves the face of the wall horizontally and bends to the vertical in the axis of the capital,(Fig. 679) from the rood screen of the collegiate church in Oberwesel).

Figs. 669 and 670, strictly taken, are to be already counted with the corbels projecting at one side, to which the latter also belongs according to their function.

Corbels projecting sidewise.

The use of corbels projecting sidewise has the purpose of forming a bearing for wall strips, beams, lintels of doors and windows, and further for all those for filling the tympanums of arches and slabs to fill above openings for doors and resting on edge, then the slabs lying flat that form the floors of balconies and bays or bottoms of gutters for water. They further serve to support springings of arches in all directions, so that in the last sense for the previously described corbels of concentric form, they appear or are combined with them as in Fig. 654.

According to its shape and function, it consists of one or more cut stones with the beds lying on each other or of one slab set on edge.

As a good form for all shapes, or rather as the necessary c cross section for them we must also assume here the triangular or swelled profile in Figs.672.and 671. The ratio of height to projection must then vary according to the load received.

There Fig. 671 first follows the form of the quadrant, which also in smaller dimensions or in simpler treatment is employed without any further addition. Partly to strengthen the upper edge, but partly to meet the fact, that every form loses a portion of its expression in execution, and hence the quadrant w will appear as a smaller segment, this generally receives an addition by a rectangle a b e f, that without increasing the height causes the centre c to move on the line ac nearer to c.

In the same manner is formed the corbel with the simple slope (Fig. 672), either by the addition of the rectangle a b e f, or just as for the quadrant by the reduced slope parallel to d b, whence results a quarter of an octagon, and the corbel projects from the face of the wall at right angles.

A lighter expression is found for the corbel by a concave a arched form (Fig. 673), either shaped according to a b, c d or b c. These shapes would then be somewhat varied by rounding the courses. The rounding becomes necessary if the centre of the curve lies so high that sharp corners result at c or d, and t then they lead to an ogee form, such as the cross section of Fig. 703, yet may indeed be replaced by a slope.

Richer forms then result from rounding, slopes and coves, by combination of similar ones as shown in Figs. 674 to 677, or from different ones, either with rectangular fillets between (Fig. 678), or without these and hence by tangency without them. Further with a more animated treatment, for example like Figs. 679 and 680 in two little examples serving as supports of the former art clock in the southern transept of Strasburg cathedral. Here as on the forms of corbels explained above the triangle forms the necessary cross section. For the good effect of the line it is also useful to enclose it in any regular ground form, even if circumscribed with a certain freedom, thus like the form of profiling between two lines, for example b d and the corresponding curved line (Fig. 681). Within the area so limited may then occur even cuttings, as in Figs. 679 and 680, although these fulfil no useful purpose.

Front edge with projecting rib.

Other forms result by a combination of different shapes of corbels in thickness, for example when in the mass of the ashlar is cut a concave form of corbel accompanied by a thinner part left in a line projecting further, which then stands on the surface of the hollow of the rib, and then serves to strengthen the whole (Fig. 682).

Instead of a lesser thickness may this rib also be formed as a square set diagonally in the entire width of the entire corbel, so that as shown by Fig. 684 it is gradually extended from the front surface. But also may the mass between the lines a b and b c project horizontally from the front of the corbel, as

indicated by dotted lines a c and b c in the same Fig. Further the entire profile of the corbel may also be wrought in the e entire thickness in the direction of the lines a b and b c, instead or horizontally.

The entire proportion of this rib to the mass of the corbel is most clearly expressed, if the latter is angular and bordered by the horizontal and vertical directions so that the rib supports the horizontal surface from the vertical (Fig. 685). Now in the same manner also the horizontal underside a b, against which is placed the rib for its depth, would be supported by the sides of the latter, and thus results the connection of both parts a chamfer, a member, in brief a continuous corbel.

Particularly often that projecting rib receiveu the form of a cusp, at least in the later periods of Gothic art, and generally so that the cusp is inserted within an arch. Also in the last case as in Fig. 686, it man have a rectangular section, so that its sides may form a tangent continuiong the line of the cavetto, or also in a similar manner it may be subdivided as in actual tracery, and then as there have the same connection with the mass of the corbel.

Chamfering and moulding the angles.

But also the angles of simple corbels as represented in Figs. 671 to 678 may be chamfered or moulded (Figs. 687 to 689). But this moulding may be wrought through the upper bearing area, only when it is continued in the supported part, arch or slab, and must in any case pass into the square beneath it. Just as little may it enter the mass of the wall, but must in the simplest cases stop on the surface a b c (Fig. 689) built in the face of the wall. Likewise results the simplest transmission from the moulding to the square at the upper end of the corbel, because the former is wrought on the front edge of the corbel, for which purpose a movement differing from the line of the corbel must be assumed, as given at d e in Fig. 689. But generally all kinds of transitions are applicable here, and by their use is already given the means to produce richer forms. But especially suitable is shown that in Fig. 688, whereby the moulding extends around the front surface and thus contributes to the projection of the corbel.

Corbels in several courses.

That form shown in Fig. 674 and composed of several quadrants placed over each other usually receives an addition of little intermediate members a in Fig. 690, whose width remains about the same as the fillet beneath the entire width. If the corbel consists of several stones laid on each other, then it is nearest to give the lower one less depth than the upper as in Fig. 691, and to use the excess of the latter for a moulding extending around it. The construction with several stones is then expressed more clearly, if the corbel is composed of several rectangular stone blocks extending beyond each other, whose lowest is enclosed by a moulding. By such forms at the same time is obtained a greater width for the upper surface of the corbel, whereby the upper portion may consist of two parts with an abutting joint. In its further extent these forms agree with the arrangement of concentric corbellings.

Development of the front surface.

Richer forms are further obtained by decoration of the mouldings, both those on the edges as well as those forming the f front. But further and in the most effective way according to the analogy of the forms of capitals, and thus by forming the mass of the corbel like a cavetto, whose upper edge is then supported by a leafy bearing. According to the scale of the p proportions of the front must then the supporting leaves be more extended than for the capitals. The treatment of the supporting leaves may then correspond to the side projection of Fig. 5?7. (A particularly beautiful example of this kind is f found in Viollet-le-Duc, Vol. IV, p. 312).

Further in the same manner as on capitals, this bunch of leaves is usually found in a double row, and also some such supports bend out from the front of the corbel and animate the entire form, or are also replaced by applied leaves as on the c capitals. Likewise sometimes the supports are replaced by figures attached to the front, as under the upper roof gallery in the south transept of the colleciate church in Colmar, for then generally the mass of the stone lying outside the line b d is utilized for any ornamental form, that must be cut on the surface within this line if it retains its character of an actual support.

Likewise retaining a geometrically limited outline may be c connected the arrangement of richer leaf ornament, that lies

in the hollows formed between the rib and the mass of the corbel in the mode of Figs. 682 and 684, about as given in Fig. 683, or on a corbel with chamfered edges extends from the front over the chamfered surface and this finally covers the entire corbel as a single great leaf as in Fig. 669, or as complicated scrolls. In this case then the cross section of the corbel also takes a changed form projecting concentrically.

More rarely is found the arrangement recalling the antique by a great leaf only covering the front, as on the corbels beneath the cornice slab of Notre Dame of Dijon. On the contrary is first of all on corbels used as supports of lintels of doors is the use of little crouching figures or of monsters crouching thereon (Fig. 693 from the western doorway of the church in F Frankenberg).

Development of the sides.

Far less important in effect and without relation to the proper function of the corbel is an ornamentation of the sides, as by means of sunk panels, usual in modern architecture. The construction of the corbel-like tracery with a slab set on edge sometimes in late Gothic led to a treatment of the sides like tracery, even to the perforation of the entire corbel, so that it assumes just the appearance of a piece of tracery, as such was already introduced by the addition of the cusp. But the p perforations here are very injurious to the resistance, as justified by the function. Yet such forms on the old works generally contain a structural principle, that confers on them a c certain meaning, though superficially. Such an example is offered by the corbels under the gallery in hre south traysept of S. Severi in Erfurt (Figs. 694, 694a).

The same are formed as pointed arches with free piers projecting from a wall, yet so that the spandrel projecting from the wall passes through the crown of the pointed arch and entering at the upper end of the pier as a quadrant supports it. The s space between the upper part of the arch of the quadrant and the front part of the pointed arch is filled by open tracery, and the pointed arch has cusps. The principle of the entire shape, whose motive is required in Figs. 694 and 694a, is accordingly based on the hanging arch (p. 78), yet is more clearly expressed, since the proper support of the whole is visible in the mass formed above the quadrant. The piers thereby supported

serve at the same time as abutments of the arches in Fig.694a, representing the front view, extending in the longitudinal view and supporting the front edge of the slab and also with cusps, above which the spandrel is again perforated as tracery.

The inexhaustible wealth of forms of Gothic corbels, that we have endeavored to indicate in the preceding, we cannot refrain from comparing the manner in which the same forms are treated in modern antique art, and partly so. The ground form or generating curve is the line represented in Fig. 695, and the only freedom in its use consists in the position in which it is placed in the horizontal and vertical directions.

For either a b may be the vertical and b c the horizontal direction or conversely, and likewise d e may be vertical anf ef horizontal or conversely, and finally the same alternation may occur with the lines i g and g h. Besides these a diversity recalling a slight change is added when b c is vertical as a new volute dotted in our Fig. Further variations then consist in the number of turns of the volute, the form of the eye as well as of the anthemion or palm leaf, which fills the spandrels at the sides, and the leaves which lie on the front of one volute beneath the other. To Grecian and Roman and even Renaissance architecture such monotony.is foreign, for the former first develops the entire motive and indeed in a far more perfect way, but the two last animate it by the magnificence of its sculptures and manifold ways, but in our times the reversing indicated by Weinbrenner to Schinkel and with the latter lasts till the present time.

Connection of corbel with the supported parts.

The connection of the corbel with the parts supported occurs in the most varied vays according to the purpose. The upper s surface is dressed plane and the beam or cut stone is laid thereon. When at the same time any movement in a horizontal direction is prevented, as by the placing of the ridge plate of a shed roof will it be doweled, or there is left a raised margin rising from the top of the corbel, as a b c in Fig. 696.

Covering slab laid thereon.

The connection with a covering slab is by a direct bearing. The slab may be in line with the extreme projection of the corbel, the lower edge being chamfered is moulded between two cor-

corbels, the moulding either stopping square before the support, or turning vertically is continued along the corner of the corbel (Fig. 297). It may further project above that by a continuous moulding, and this projection either recedes by a wash to the line of the corbel, or continues on the vertical slab and further on the face of the upper wall or parapet.

While in antique architecture the forms of consoles, modillions, etc., allied to corbels are surrounded by a moulding at the upper edge, but which is actually wrought on the slab and from the beginning according to the depth of the undercutting, so that as shown by Fig. 699, the ogee a is broken around the console and between them is worked through the plane b, this weakening of the middle of the slab is found to be avoided in Gothic architecture. On the roof cornice of Notre Dame in Dijon this conversely receives a strengthening by the rosettes projecting from the underside between the corbels (Fig. 698). The slab requires no undercutting since the removal of water is done by the mouldings above.

Slab on edge between corbels.

Setting a slab on edge on the supporting corbels varies according as the slab stands in the direction of the corbels as on lintels of doors, tympanums of arches, etc., or makes an angle with them, most simply a right angle, as for example the arch a b in Fig. 694a, that may also be formed of one slab. I Transverse slabs sometimes have an entirely peculiar treatment, particularly on mantles belonging to the 15 th century, which represents the transition from the covering with a slab to that by vaulting. The jambs of such mantles are generally formed of slabs set on end and receive a corbelled form at their upper ends, by which the necessarily wide projection of the smoke m mantle at the ground is changed into a narrower one less restricting the area of the room, and bearing the slab set on edge and forming the front surface of the smoke mantle.

There for removing the projection as far as possible from the ground, it came to allow it to project to the lower edge of t the slab when possible. But then the slab could not be laid abruptly on the jambs, but as the perspective view in Fig. 600 shows inside and Fig. 700a shows outside, it is notched on the jambs as at a b c. This construction then leads to the usually repeated treatment represented in the same Figs., whereby the

outer half of the rib moulding forming the edge of the slab p, but whose inside is formed by a simple slope d e in Fig. 700a of the same height as the profile of the rib, that likewise c continues on the jamb at g in Fig. 700 and intersects the inside half of this moulding.

Arch and vault between corbels.

Now if the slab is to be replaced by an arch, thus first by a straight arch, the jambs must be so deeply inserted that the mass of the masonry between them cannot be crushed by the thrust of the arch acting as a lever, and have a sufficient strength not to be broken at the face of the wall by this force.

Likewise instead of the straight arch may be employed any other form of arch, and the abutment of the arch pe wrought on the corbel or on a stronger ashlar laid on it. The arch can be used to support the front edge nf a floor slab as in Fig. 694a.

Further the covering slab may be entirely omitted if the cross arch continues to the entire projection of the corbel from the face of the wall, thus to a tunnel vault turned between t them. Such an arrangement is found for every width of projection, but especially in that continuous corbelling, that either carries a projection of the upper above the lower face of the wall, or is to serve as the required support of wall beams. Sometimes as shown in Fig. 701 the lines of the arches continue above the corbelled support at its middle.

More favorably is received the thrust if the tunnel vault is replaced bn several concentric cross arches stepped slightly under each other, whose abutments are wrought either on the inner sides of the corbels, or better project from them, so that the sides are wrought with the projection of the inclined joints concerned. A very thoughtful arrangement of this kind, which corresponds in principle about to Fig. 702 is found beneath t the bay window of a subordinate building of the castle of Meissen, where by projecting continued and different cut stones results the support. The Fig. will make all explanation unnecessary.

There is sought the design of a cross vault between two corbels, since here the special advantage of it, obtaining height, is useless, but the effect of thrust remains about the same. Like the total thrust of the tunnel vault on a lever arm corr-

corresponding to half the projection of the corbel, so is the effect in the cross vault of half the thrust on the entire projection of the corbel as lever arm, while the other half acting against the face of the wall may be neglected. The only difference is that a part of the thrust acting in the direction of the projection of the corbels acts in an opposed direction, a and thus vanishes, it being always assumed that the abutment or springing of the rib is wrought in the corbel as shown in Fig. 70a. The tension in the upper part of the corbel is thereby increased. If these springings of arches are wrought on separate stones laid on the corbels and not built into the wall, such a construction is allied to that used for vaulting beneath a bay window, and thus generally the plan of windous in the sides of the bay window courses, with the greater part of the load acts on the ashlar under the angle pier, and thus ensures its position, and this makes a special point for receiving the thrust of the cross vault resistant.

Angular position of the corbel.

As a rule, corbels project at right angles to the face of the wall. But where the projection is to be continued around the corner, there generally for the better support of the slab, a corbel is set diagonally, conversely to the antique arrangement, according to which two were set at right angles at the corner, and the surfaces continued, but both came to be wrought from the same block, so that the corner of the slab remained without support. The diagonal corbel must then for its greater projection have the same proportion in height, strictly taken, or it may have the same height if the arrangement is found as given in Fig. 704, whereby the projection of all corbels remains the same. The arrangement of a diagonal corbel becomes an absolute necessity if the plate laid on it is replaced by arches.

If the line of the projections from the wall varies, then in the simplest cases, if by the projection a polygonal area is obtained, then must the corbel either be perpendicular to the face of the wall or to that of the projection. Figs. 705 and 705a show the first arrangement, according to which the arches a b turned beneath the oblique sides of the octagon on the face of the wall, also intersect obliquely the sides of the corbels, so that to the latter is added the abutting block suited to re-

receive this arch, and shown in perspective in Fig. 705b. An example of this kind is found under the bay window of the Princes' hall in the city hall of Breslau.

The position of the corbel perpendicular to the line of projection and oblique to the face of the wall is only possible when they leave sufficient space between them on the latter to be able to extend to a sufficient depth in the wall. But then the projection and accordingly the height of the separate corbels will be different.

Arched corbelling.

Here belong the supports of bay windows, pulpits, turrets etc., very frequently employed in the later periods of Gothic architecture, corbels formed as parts of arches as shown in Figs. 706 and 707.

Concentric treatment.

In such corbels the crown of the vault rises in the air, the keystone or ridge arch of an actual vault being replaced, either by a knob attached to the lower edge of the upper slab as in Fig. 707, or by an arch as in Fig. 706a extending horizontally and continuously beneath the same edge, as in Fig. 707a. It might appear as evidence of the caprice of late Gothic architecture, that two such different forms as a corbelling and a vault should be formed according to the same system. But a closer investigation shows, that the arrangement of such corbellings is based indeed on a labored, yet still always a structural principle. For any half of a vault may have its entire stability, when the counter thrust of the other half is replaced at the crown by the resistance of a wall or by anchoring. Thus in Fig. 796a the arch h c forming a half arch may be turned w with the least material, when the crown c is ensured against yielding horizontally by an iron anchor, and between two arches constructed in this way may even be turned compartments. But in Fig. 706a the iron anchor is more skilfully replaced by the slab f c a b d e built in at d e and ensured in this position, so that between the springings a b of the arches and the lower corbel b are likewise turned vault ribs, allowing compartments to be turned between the latter. If now as generally occurred, the entire form was built of horizontal layers, so that arches and surfaces of compartments as well as the springings of arch-

arches rest on the same blocks, then this arrangement only calculated for less material for the change to the more convenient mode of construction (as already on the Greek columnar orders the forms of certain parts must have been derived from wooden construction and from a different material), and the strongest objection to the entire form might be sought in this, that it does not plainly exhibit its construction, so far as it is impossible to see it externally, for example whether the middle block in Fig. 706a is ensured by a deep horizontal bed a b, or that it extends between the slabs placed above and below, and therefore has the shape given by the dotted lines.

The construction of the ribs in the same stone as the compartment, whereby the thickness to support the former must be wrought on the latter, then leads to the arrangement of a complex scheme of ribs and at the same time the height of the rib is limited, so that the front edge of the upper slab c must not be undercut too much. This undercutting may however be reduced, if the rips are joined with the mass of the compartment below the edge in the manner shown at the springing of the ribs as shown in Fig. 287a, so that the surface of the compartment extends under the edge according to the dotted line in Fig. 706a.

Continuous corbelling.

Such corbellings are to be formed by producing a concentric as well as a continuous surface. In the latter case (Fig. 707) the form of the net vault is the basis. A very artistic example of the last kind is found under the beams of the city hall in Cologne at the side next the Neumarkt.

The construction of such a corbelling and the arrangement of the joints are according to the nature of the material. If the ashlars are sufficiently large to place the highest bed so high, that the arch line is not too pointed, but intersects at an angle at least of 60° to 70°, then may it be laid horizontal, if above all the jointing of the stone allows an acute edge. In other cases with smaller or coarse-grained material, it is better to make the bed joints in front like the notching in wood construction at right angles through the arch lines of the ribs and the body of the compartment (see a b d), so that in the p plan of Fig. 706b, f f indicates the surface of the radial joint.

More complex will be the arrangement of a corbelling formed like Fig. 707, since here the beds of the ribs lie in two dir-

directions intersecting at an angle as shown in the perspective of Fig. 707a and the plan of Fig. 707b. The lower ashlar A enters the wall like the springing of a rib, and on the upper edge extends the radial bed surfacer f and f′ on three sides. On the bed surface f′ then lies the ashlar B, on which is wrought the intersection of the ribs. The sides of the latter (s in Fig. 707a) remain vertical and on the upper edges are wrought again the radial joints f″. On the joint surface f and between each two blocks B then lie the intermediate blocks C, on the upper edge of which continue the radial surfaces given by a e, so that the blocks of the upper slab D, that extend back into the wall and on which rest the uppermost parts of the ribs, are placed against the latter according to the extended surfaces d c b a e.

The stopping of the ribs under the upper edge of the corbelling is then found changed, so that the rib breaks around this edge and intersects the profile of the slab (Fig. 708). On the graceful pulpit of S. Blasien in Mühlhausen the profile of the rib projects beyond this edge of the wall of the parapet, and stops beneath the breast moulding of the pulpit, so that is p produced a moulded post at each angle of the polygon, and the surfaces between each two posts are ornamented by tracery.

Likewise the tunnel vault can form such corbelling, and then is formed a simple cavetto without ribs, or also with ribs the form in Fig. 709, indeed here the structural principle is clearer and the entire form is one fully justified. For in Fig. 709 the upper ashlar A enters the wall deeply and is anchored to it by the loading or by dovetail ends, so that here not only the lower blocks B of the ribs extend between them and the wall, but also the front block C of the upper edge holds its place by an oblique joint d a lying in the horizontal plane, and need not enter the face of the wall, and thus the slab proper may be omitted. But this block forms the ridge of the tunnel vault D between the ribs, which can therefore be executed in small pieces of material.

The use of the same construction in Fig. 707 also then leads here to fasten in the wall only the pieces on which the ribs intersect below the margin, extending between them the pieces of mouldings, so that here are avoided even the inclined joints seen in Fig. 709 at d e, replaced by the joints of the ribs ((Fig. 710). But in the last form the construction still has the

utility, that it allows placing the openings over each other, indeed is based thereon, so that if in Fig.710 are formed arched openings under the side arches, that start from the piers a, the upper piers stand over the crowns of these arched openings. Such constructions naturally cannot receive great loads.

Some purely ornamental forms are still to be mentioned.

The undercutting of the dege of the slab is seen at c in Fig. 706a, since the joint a b prescribes a greater height for the stone cut away in front, leads to the use of this height for arranging suspended arches extending around beneath the edge of the slab, that are preferably in place when the body of the projection is without ribs, but also generally occurs in connection with moulded corbels and at every scale. Likewise for the proportions of the stones for the arrangement of cusps on the edges (Fig. 711), and further for the arrangement of more or less undercut and even perforated tracery before the body of the projection as if enclosing it in a cage, an example of which is given by the pulpit of S. Leonard's church in Frankfort, as further all forms of ribs mentioned later in Figs. 95 to 102 are also employed on such corbellings.

Brick corbellings.

As generally the possibility of forming the greater and richer corbellings depends on the size of the materials, brick thus lends itself to it only with a certain difficulty.

Corbellings at a smaller scale as under the beginnings of r ribs are found made of terra cotta in a single piece, and only treated with less freedom than stone. Examples of this kind are shown by the remains of the Cistercian abbeys of Chorin a and Hude near Bremen, the castle of the order at Marienberg, etc. But obtaining greater projections is only possible by the continued projection of the upper courses beyond the lower ones, which may then occur in ways with or without the use of specially shaped bricks. Fig. 712 exhibits the different arrangements possible in a single example.

Simplest and nearest is the projection of the different courses over each other in ordinary bond as indicated from a to b. To secure a stepped ground surface with lesser projections sidewise may end in the manner shown between e and f. In the last way can a simple rectngular ground be produced by carrying higher the side projections up to the outer face. By adopting the

diagonal direction of the joints otherwise genera
on the whole the ground form of the diagonal squa
which then by a combination with certain bricks i
position, either as at d or d′ the ground form of
gle at c is again obtained. The position of the b
at d′ is employed diagonally above c, and forms o
most useful means for forming a continuous corbel
cornices, that causes a different effect accordin
ber of courses lying on each other, as well as th
which the upper project beyond the lower, or inde
to how such courses alternate with one in the ord
on. At g is further shown a corbelling with a cou
edge. But likewise also could certain bricks be p
the same position as the course on edge, and then
by a simple or stepped covering, or by bricks set
other in gable form as at h. Likewise are arches
for small corbellings as indicated at i for the e

Stops at moulded angles.

To corbels are allied the stops that change fro
polygonal or moulded part into a rectangular one,
moulding to a polygon, and at a larger scale on s
of doorways, or at a smaller one at the lower or
a pier, jamb of a window or doorway, etc., in a s
as a substitute for the plinth or capital. They c
en construction on moulded girders, beams, framew
everywhere that a connection of two similar timbe
the plate rests on the ends of beams and the beam
wall.

In large size this became actual corbellings ar
cuted io each of the modes mentioned. A simple ex
. form in brickwork is found on a hexagonal stair
church of S. Egidius in Lübeck, whose upper story
a square, indeed only by a series of ordinary cou
the direction of the sides of the square and thus
the surfaces of the hexagon.

At a smaller scale especially the upper and low
moulded edges come in question, that may receive
geometrical or a richer and ornamental treatment.

The geometrical forms even in great simplicity
quite manifold shapes (Figs. 713 to 723). Those i

moulding may pass into the square by a movement toward the angle as indicated by the lines a 1 b, c d, but in elevation by a horizontal band or by oblique ascending lines (Fig. 714), or this may occur by the most varied curves (Fig. 715), so that the different members diminish to the point and join there; thus further in the same Fig. 713 are possible the indicated parallel course of the mouldings toward the side of the square, and indeed again by curves, by oblique or horizontal lines (Fig. 716), whereby the actual or a distorted profile appears on the sides. Instead of the same a different or reversed profile may intersect the moulding (Fig. 718). The appearance of a cut-off profile will be avoided if the moulding extends to the angle and returns on itself according to Fig. 717.

A different ending results from the penetration of a plane by the moulding, first included. This may be inclined diagonally as from b to e in Fig. 713 (See Fig. 719), or it may be arranged to rise steeply at one side with a horizontal edge at the other (Fig. 720), or even forming an edge less inclined (Fig. 721). The change may be formed by two planes forming a gable (Fig. 722) or an ogee curve (Fig. 723) is suited for chamfers or simple mouldings. The same arrangements may occur if the transition is to be made to the polygon. Here belong the late Gothic plinths executed in Figs. 574-581, whose principle consists in the change from one ground form to another.

Generally treated stops were preferred in the Romanesque and early Gothic times (Figs. 724 to 726), and they form an abundance of ever novel solutions. Finally as a most effective treatment of the angle in the earlier centuries is to be mentioned the inserted angle column, that finds manifold uses on piers and the stepped angles of portals, and in consequence of the limited projection and of the peculiar onesided development of capital and base has produced forms suited to the purpose.

FORMS OF PLANS OF CHURCHES.

1. Church with single aisle.

Direction of the church from west to east.

Already from the first centuries Christian churches of every ground plan were arranged with their principal axis extending from west to east.

For the eastern location of the choir are rules dating from Christian antiquity, whose innate reasons are found in Kreuser (Note 1) and Otte, Note 2), and still at the present day are as valid as in the beginning, and are also again generally followed in modern times. If it would accordingly be absurd to d desire to strengthen those innate reasons by external ones, we cannot refuse to emphasize the unfaporable results of neglecting them.

Note 1. Christian Church Architecture.

Note 2. Manual of Archaeology and Ecclesiastical Art.

However greatly the tendencies of men diverge in every worldly respect, yet for the Christians without difference of creeds, their one tendency toward the triune God is expressed in the same direction of all churches toward the East. The reasons t that since the 16 th century led to variations are all comprised in one, that the eye is accustomed to symmetry and might feel shocked by an oblique location, which the course of the streets opposes to the orientated church. If we yield for the moment to this injury to the trained eye, yet it cannot be assumed that the same eye will be less sensitive to the entire effect of a city, than to the view of a street or square. But manifestly in spite of all magnificence of railway stations a and manufactories, yet the churches by means of their bodily and monumental grandeur determine the character of the general view. let one once view one of those beautiful cities that has retained the splendor of their old churches like Lübeck, Nuremburg and Mühlhausen, and then thing of these churches suddenly displaced in their locations and diverging in different directions, and seek to present the image of confusion and lack of harmony which must thus result.

Less glaring indeed, yet just as objectionable are the impressions, that one may receive actually in those cities where the number of their old churches has been increased by new ones, almost without exception inferior to the old in dignity and

artistic importance, thereby perhaps even expressing a negative scorn against the location of the old indicated arrangement.

And is it then the impression produced by the divergence of the churches in the interiors of the cities a satisfactory one? Is there not something even comic in it, if as sometimes occurs, when the doors of two churches on either side of the same street invite one to enter?

Might one therefore not leave to the non-Christian religious societies, whose temples are not yet great, the divergent directions or those toward each new grand East ? (Several years since occurred the case, that in the erection of a new church the building officials desired to recognize a passing railway as such), to retain for the Christian church the old sacred direction eastward?

The divergence of the longitudinal axis from the East line occurring on so many mediaeval buildings is explained by the change in the location of sunrise according to the time of year (Note 1), as uell as sometimes the slight divergences of the direction of the nave from the choir, where both parts join at an obtuse angle, as in Erfurt cathedral and S. Maria Stiegen at Vienna, from the difficulty of establishing the line of the building in the space hemmed in by other structures (Note 2).

Note 1. Journal of Christian Archaeology and Art.

Note 2. Viollet-le-Duc. Dictionary of Architecture.

General ground plan of churches with a single aisle.

Plans with one aisle were employed at all times of the middle ages not merely for simple chapels, but also for parish churches and those of the orders, and they sometimes appear in great connected groups. There may be recalled the domed churches in southwest France (Angouleme, Fontevrault, Souillac, Gensac, etc), that with a span of the dome of 10 to 12 m. mostly form quite imposing interiors, and further reference may be made to numerous single aisled churches of the 15 th century, that with buttresses included in the interior attain mighty widths of 18 m. and more in the clear.

Seldom is the ground form a simple undivided rectangle, yet even in the smallest chapels is expressed at least the choir, whether with a polngonal or circular ending, by the reduction of the width and height of the eastern choir bays, or in an e expensive way by the insertion of a separation transverse aisle.

in the last case may appear side apses and a chevet, and in g generaly may occur in execution all the rich choir plans possible to churches of several aisles (see farther below).

The western termination may be by a gable wall with or without vestibule and stair towers, and it may form a developed arrangement of towers.

Ground form of choir ending.

The usual name of choir was originally only for the part of the presbytery lying next the nave, but is now generally understood for the eastern structure containing the altar, and whose ending is distinguished as the choir ending or head.

As the location of the altar, the choir is in such a high degree the essential part if the whole, that it may very well exist without a nave and even may form an entirety, such as found in many little chapels, where the free space outside for the community is limited and hence replaces the nave. On the contrary the converse condition is inconceivable, since no church can be conceived without an altar, which for the latter and t the space required for the communion there must be divided from the interior if it does not project entirely. Such an arrangement where the space for the altar is not indicated externally, therefore in architectural language is a denial of the sacrament of the altar to those without the church, and therefore is inadmissable in Gothic architecture, since its nature is to be sought particularly in the greatest truth and clearest emphasizing of all conditions. Accordingly must the choir with its ending project from the body of the church and differ from it, if not in material size, yet by the peculiarity of its ground form and the treatment of its elevation.

General form of the polygon of the choir.

The plan of choir endings most commonly occurring on Gothic works are with 5 sides of the octagon (Fig. 727) or of the decagon (Fig. 728)., or 7 of the duodecagon (Fig. 729). The latter forms have the disadvantage, that a pier stands in the longitudinal axis of the eastern window is lost. All these polygonal forms originated from the semicircle and first differ in whether they are circumscribed by a stilted semicircle (Fig. 727) or by a semicircle as an exact half of the polygon (Fig. 728). The first has the advantage, that it makes possible an easier transition from the plan of the polygonal vault to that of the

adjacent rectangular bay, while the system of ribs going to the centre of the polygon has an independent termination within the partial polygon, which in every half or smaller portion of the polygon is only possible by moving the keystone into the choir ending, if this is moved from the proper centre c of the polygon to c′ as shown by Fig. 729. But therefore the eastern ribs of the bay with the same height have a smaller span than the western, and the entire arrangement has the character of a mere expedient. For the choir ending with 3 sides of the hexagon the course of the ribs thus passes into that of the cross vault over a trapezoid (p. 27).

According to all the plans mentioned the choir polygon has a width equal to the parallel elongation. But it receives a greater one if the radius of the circle on which the polygonal form is based exceeds half the width of the rectangular bay, the choir ending being formed as 7 sides of the decagon, 6 sides of the octagon, 9 of the duodecagon or 5 of the heptagon. (Fig. 732). This arrangement is found in certain Rhenish and Westphalian churches, thus in S. Peter and Maria in the desert in Soest from the decagon, in the church at Sayn from the octagon, in the minster at Aix-la-Chapelle from the polygon with 14 sides, but is also in the Baltic provinces, and it has the advantage of obtaining a considerable enlargement of area for the choir, and even makes the omission of the parallel elongation possible, while the choir polygon directly adjoins the triumphal arch indicated by a b in Fig. 731; but then causes a particularly simple connection of any side choirs with the high choir. Yet the increased width seems without purpose for the worship in general. Herein must be the reason, why the arrangement found adoption restricted to certain regions in spite of its other advantages.

With the polygonal choir ending is also to be counted further the rectangular one. In large proportions this is found predominant in the churches of the Cistercian order and in English works, but in more moderate dimensions is very common in Westphalian provinces and in Prussia, and finally in naves without vaults in some village churches still in the Gothic style, and which we shall mention only mention in the church of Schwarzenborn and that of Nieste in Hesse. In the last combination must indeed be given the minimum of a Gothic church building. Unfor-

Unfortunately an approximation thereto is rather given in existing conditions rather than in the earlier, anf therefore the study of such poor warks is not without importance. Fig. 733 shows the plan of the church at Nieste.

In the early Gothic works in France the semicircular choir ending is still the rule, and for example is found in the cathedral of Rheims in the way that the sill of the windows terminates the circle, and the windows thus form the transition to the polygonal form. A Gemman example of the same kind is shown by the eastern choir of the cathedral in Bamberg. But by the choir plan with aisle and chevet chapels consideration leads to a regularly forming of the chapels on a polygon of unequal sides.

Little shafts in the choir.

In the angles of the polygon stand the rounds on corbels for receiving the ribs of the vault. Determination od their number and diameter depends on the arrangement of the vaulting system. In the simplest case assumed in Fig. 734, only one round for the diagonal rib finds its place, whose diameter cannot exceed the width of the latter. This may be increased if the projecting side arches also must rest on the capital of the round.

If separate smaller rounds are to be arranged for the side arches, then those intended for the diagonal ribs must be set farther out according to the construction shown in Fig. 734a. It is then common to project the internal face of the wall below the windows of the dotted line 1 1, so that the round supporting the side arches stands on the window sill or the moulding extending around .

Plan of the windows:

After locating the rounds the plan of the windows is to be drawn. With the greater development in width these would entireln occupy the width between the buttresses, but in Germany they mostly utilize only a part of it. For the general effect in the interior as on the exterior, it is then advantageous to allow one thing to predominate, the mass of the wall or the width of the windows. For a small breadth up to 1.20 m, the windows best remain undivided, since too small a width resulting from a division of the windows injures the effect of the glass, and likewise that of the arches and makes the tracery placed in them seem puerile. Yet by the later works have men

become too much accustomed to regard the latter ar an essential part of Gothic church windows, and conversely to attribute far too little importance to the glass. The opposite condition is more suited to the nature of the facts, and causes a better effect as shown by so many early Gothic works. Meanwhile even here much depends on the local conditions. For example where is concerned the construction of any smaller included part of the church as a chapel, sacristy, etc., the small dimensions of such details enhances the effect of the larger ones on the church, and thereby that of the whole. In general must the widths of 0.50 and of 1.20 m be the limits of the breadth of the windows.

The most common division of the width of the window is that by a middle mullion into two panels. The proportion of the width of the mullion to that of the panel is determined by the m material and the limits of working and durability, when the l latter is opposed to a continuing diminution, and further it it is greater on early Gothic works than on those of later periods. Thus in the windows of S. Elisabeth's church at Marburg, it is 11 to 35 mm, in the church at Haina 1 : 3, the church at Wetter 9.5 : 2[illegible], thus about 3/8 to 1/3, and in the later works it rises to 1 : 5.5 = 2/11. The extremely weak mullions of the late period therefore can maintain themselves only bn the iron bars extending through the arrangement of the glazing and give to it a meagre effect not far removed from that of cast iron. Indeed the great public, always inclined to regard it as artistic, is accustomed to find the greatest pleasure in all such very ulender parts, it was perverted by the long period of absence of taste, the preference of deceptive counterfeits to an openly reasonable construction, and thus can one experience in general, that in the works erected at different periods, the latest parts find most admirers. Yet quite otherwise would also here be established the proportion of estimation, if in works entirely executed in the style of early Gothic is found one opposed to that belonging to the late Gothic, yet neither more costly nor novel, and thus the harmonious effect of the earlier could enter into its rights.

The depth of the mullitins exceeds their breadth. With the mullion is connected the glass and iron work of the window, and

therefore is generally found a half mullion at the window jamb, tte so-called wall mullion, yet this is absent on certain early Gothic works. Consequently the wall and middle mullions are c connected, at bottom by the sill and at the top by the tracery, in the entire height by iron rods to which the glass is fastened, as well as by the last, thus forming a wall that is placed farther inward or outward en the thickness of the wall or is ordinarily at the middle, requiring the character of such jamb mouldings.

As a rule all windows of the choir have the same size. Yet sometimes in the simpler plans the east window predominates o over the others in form and size, thus for example being divided in two parts with tracery above the mullion, while the latter are single pointed windows. This simple arrangement shows an entirely analagous accenting of the line of orientation, as expressed in these rich choir designs with aisles in the arrangement of elongated chapels of the Virgin, and thereby produces a very happy effect. The east window is sometimes walled up a and decorated externally bn a figure of S. Maria seen afar. (Erfurt and Marienberg.).

The east window as a point for the eye must always have a p particularly dignified colored painting. In many new churches the glaring light of the colorless window hurts the eyes and gives the altar an unpleasant lighting from the rear.

The window is sometimes made so wide that the side arch for the vault coincides with the largest window arch, indeed the enlargement may proceed so far that the outer splay of the jamb cuts into the mass of the buttress, so that the wall mullion directly joins the latter and the arch of the jamb starts from its face.

Increased upper thickness of the wall.

In the last manner may also be increased the thickness of the upper part of the wall, if concentric with the window arch or excentric thereto, an arch indicated by the dotted line in our Fig. 734 extends between the buttresses or rests on them by c corbelling. Examples of this kind are shown by the choir of young S. Peter and S. Thomas in Strasburg, a bay from the former being shown externally in Fig. 738, as well as in S. Elisabeth in Marburg. This increase in the thickness of the wall may

be required by various reasons, both b: the design of the roof and to make the gutters more easily, (in which case it extends above all bays of the vaults and is especially necessary when no side arches projecting inward exist; ,and hence the necessary thickness of the wall is taken for the support of the compartments),as well as for the base of any superstructure, but in the last case it may be limited to one bay. On the eastern bay of the cathedral at Erfurt is it found with rich mouldings in the last sense.

Place of the wall with regard to the buttresses.

A happy effect results when the wall within the limits determined by the width of the buttresses is placed farther outward, so that the head of the latter is expressed inside by the angle a b c, as shown in Fig. 734b, which either receives the otherwise moulded side arch on a capital or can continue unchanged in it. Such an arrangement, by which is reduced the projection of the buttresses, is found in the nave of the church at Wetter (Fig. 737), in the nave of the Minorites church at Duisburg (Fig. 735), and in the choir and transpets of the church at Haina. In both the latter examples the wall beneath the window sill is set out to the outer face of the buttresses, so that this projects above the corbelling from the face of the wall at the height mentioned.

A combination of this arrangement with that previously mentioned results when to the internal angle a b c in Fig. 734b c corresponds the external angle d e f, so that the side arch extends through the thickness of the wall and also bears the roof structure, while the thickness of the wall is reduced between the piers e d, b c, i.e., in connection with them and as under the last connecting arch. Here the pier e d f is not visible on the floor, but the parapet wall of the window may set back in the face d i, and either receive inside the entire thickness d a, or remain with less thickness as indicated by the dotted line.

In the first case the great thickness of the wall makes possible even with limited dimensions of the whole, the arrangement of the blinds and cupboards serving for various purposes. Otherwise the projection of the upper wall beyond the lower part, therefore the thickness g k, or if the conditions are reversed the g k becomes the lower wall, the thickness g i

beneath the window sill is spanned by an arch, and in this way the arrangement of the galleries is allowed in the most varied manner, as will be explained later. A varied treatment of this arrangement is found in the archbishop's chapel at Rheims, where the wall between the buttresses is set out so far as to p permit passages to be formed between the lower parts of the latter and the face of the wall.

On the church of S. Catherine in Oppenheim the wall is further placed entirely at the outer face of the buttresses, so that it gives a space beneath the window sills of the side aisle. On many French cathedrals as at Paris, Amiens, Rouen, Meaux, and also on the choir of the Frauen church at Bamberg, etc., with the exception of the last, these include the entire height of the side aisles between the buttresses in chapels built later, and on certain German churches of the late period with the arrangement of aisles of equal height, the wall is placed flush with the outer face of the buttresses, so that in the interior are formed deep niches as in Fig. 736, S. John's church at Riga (from the drawing by A. Reinberg at Riga).

Therefore while according to the Oppenheim form the buttresses are visible externally above the chapels, they appear in French works first above the side aisle, thus in relation to the buttress system. On the late Gothic hall churches mentioned, they do not appear externally. Aside from the dry effect of the exterior, the last arrangement mentioned must already be termed the least fortunate possible for the ground, since it omits the projection of the buttress so advantageous in structural respects. It becomes still more imperfect, if the thickness of the pier extends to the jamb of the window, thus a also that the projection of the pier inside is omitted. Certainly by such an arrangement the depth of the pier can be reduced by so much, as the greater width increases the resistance. But the ratio of the two dimensions to the resistance causes, that the cubic volume as greater and hence the arrangement is disadvantageous in principle. Only in such small dimensions t that the thickness and width of the buttress are small in regard to the conditions of the material, can such an arrangement be right, for comparison of the advantages and defects of the external and internal projection was made a statical investigation first for the external buttresses and then for internal

buttress projections, for the same church with one aisle of 14 m span and 7 m length of bay with 20 m height of wall. This g gave as mass of the abutment for one bay (including the wall panel) for equal resistance in the first case 124 and in the second 156 cu. m. of brick masonry. The masonry required is thus in the proportion of 4 to 5. But then it must not be overlooked that with internal projection is opposed to the greater volume a certain advantage by increasing the internal area.

A great diversity in regard to the forms of abutments is shown by the Minorites' church in Duisburg in its various parts. (Fig. 735). In the polygonal choir is here found the usual arrangement of rounds with buttresses projecting externally, which then in the parallel parts of the south side of the choir is then strengthened by segmental wall piers projecting inside. Also in the nave these internal piers essume a rectangular plan, become deeper as they reduce by the same volume the external buttresses, while in the north side of the choir the face of the wall is placed in the outer face of the buttresses, and w with the smaller width of the choir the internal piers again assume a weaker form before the thicker wall.

This varied arrangement likewise allows the utility of the buttress to very clearly appear. For while on the north side a part of the wall to a height of about 48 ft. contains 8256 cu ft, the volume of the corresponding portion at the south side amounts to only 7488 ft. In this the projection of the buttresses and the deduction of the window openings are not made, which are lacking on the north side. Still greater would be the difference in volume, if the foundations were taken into the account.

Combination of the choir with a nave of equal width.

Side of the folygon falling in the longitudinal direction.

The side b i of the polygonal choir facing in the longitudinal direction differs from the others by the position of the western buttress, which is perpendicular to that direction. The round at i is corresponding to this buttress, if the choir polygon forms on the west another vaulted bay, then has the f function of supporting besides the diagonal arch of the choir vault, that forms the only load of the other rounds, also the diagonal arch of the added bay and the dividing cross rib i b. Therefore must the pries of these ribs either be strongly con-

condensed , the diameter of the round be increased, or finally 3 rounds are placed at i. In the two first side arches also spans from i to b, and the middle line of the window placed in the bay i b coincides with the face arch, but therefore not w with the middle of the part of the wall between the buttresses on the exterior. The external part of the wall is unsymmetrical and somewhat shorter than the other sides of the polygon. This especially in the simpler designs has nothing disturbing on the exterior, since generally the care peculiar to modern architecture not observing the bilateral symmetry of Gothic architecture is foreign to it. (Frequently these last sides are intentionally made longer than the others).

But also allow that symmetrical wall surfaces are produced internally and externally. (Fig. 734, right). If the internal pier is formed by lines perpendicular to the face of the wall at the points n and o, the walls themselves being set farther out and the internal piers being connected by the sides arches q r, then the windows in the middle inside and outside, but the distance from the round s to the angle q of the pier bearing the side arch becomes greater than that from the round to the angle r. Accordingly it seems indicated in a certain sense, to use the remaining breadth between s and q for setting the diagonal arch, that accordingly can rest either with the side arch on the corresponding part of the pier, on a corbel or round projecting before the surface. In the first way we come to the form of an internal wall pier, which either remains rectangular or can be rounded to a circular arc, as in the choir of the Minorites' church in Duisburg (Fig. 735), but in the latter way in the plan of separate rounds for each rib shown in the right half of Fig. 734.

But by this transfer of the round t to the east and the arrangement, strictly taken disappears the equality if the internal sides of the polygon. If these must remain alike, then must the round supporting the diagonal rib be exactly at the point indicated by the angle of the polygon, so that b u equals b c, and hence the round bearing the cross rib with the entire buttress must be moved to the west in the same proportion. Also we cannot omit here the remark, that it was far less for us to do for this equality, than to show on this example how easy it the principle of Gothic architecture devotes itself to give the

most suitable expression of all conditions.

The equality of the bays between the buttresses results of itself, if a nave joins directly the round standing at i, which is wider than the choir, and is separated from the latter by an arch nearly or quite corresponding to the thickness of the wall, so that only the diagonal rib rests on the round standing in the angle of the polygon.

The adjacent bays.

But as a rule the choir polygon will be extended by one or more rectangular bays of the same span, and in such a shape g gives the simplest ground form of a chapel or church with a single aisle. The length of this bay may either equal a side of the polygon or exceed it.

The number of rectangular bays depends on the length the chapel must have as well as on its proportions. It is probable for the length to predominate and be at least twice the width, but it better equals twice the diagonal or thrice the width, and **is** also the effect of the whole substantialln gains if these lengths are produced by a greater number and not by a greater length of bays.

Western ending of single-aisled churches.

Gable with buttresses.

The western termination in the simplest cases will be formed by a straight gable wall, so that in the angles formed there stand the rounds to receive the ribs, whose arrangement is brought to harmonize with that of the other piers, but stands in the most exact connection with the positions of the western buttresses.

The latter are either perpendicular to the two wall surfaces or are diagonal, i.e., in the line bisecting the angle. Two b buttresses at right angles may either form extensions of the faces of the walls, as in the left half of Fig. 734, or be set back from them, so that the corner freely appears between them, as in the right half of the same Fig. The first is simpler. B But the relation of the round to the buttresses set over in t the arrangement shows externally that the window is set still farther from the middle of the bay, than is the case for the side b i of the choir polygon. The second arrangement differs according to the distance by which the buttress is set back from the angle, and even offers the possibility of placing the

buttress exactly according to the round, thereby removing all irregularities in the interior and exterior. At u in Fig.734 is this plan developed from the assumed placing of a round at s for each rib. As in the left half of the same Fig., if all ribs rest on one round i, then the buttresses stand farther apart and the dotted line p will be the middle between them. Yet farther opens the angle between them for the corner formed by the wall surfaces, if the buttresses extend inside. Still a cean arrangement is to be mentioned, according to which a r round standing at u with another of the same diameter bearing both the diagonal rib and a side arch rib, and then the receding of the western wall at x could disappear, ro that this would retain the thickness x y.

The buttress set diagonally corresponds to the combined thrust of all ribs joining the western corner of the vault, here indicated by the diagonal. Strictly taken, for unequal sides of the bay the buttress mustleave the direction of 45° and that of the diagonal rib, just as with the arrangement of two buttresses at right angles that extends west could be weaker than the other. However this reference to the plan of the bay is taken in the direction of the buttress, but rather by increasing its length, which is usually determined so that the front corner lies in the plane of the other buttresses. But the arrangement of these western buttresses on single-aisled churches is also subject to substantial modifications by the proportions of the western gable wall.

Gable without buttresses.

The western wall requires an increased thickness, first on account of its greater free length, but then for the loading caused by the gable and sometimes by a bell turret placed on it. By this increase in thickness as well as by the load it will be placed in condition with reducing it, to resist the t thrust of the vault acting in the longitudinal direction. Therefore in certain cases the buttresses here in a western direction may be omitted, and there results at once a form, constructed in the right half of Fig. 734, so that the internal s side arches are included in the thickness of the wall.

But this thickening can be produced by moving the gable wall farther to the west, whereby in a sense the gable wall is moved to the line of the western buttresses, and therefore the exter-

external pier is changed into an internal one. This internal will then be connected with the one lying opposite by a cross arch (Fig. 739), which gives the western wall the required increase in thickness and a broader base of the gable and the added turret. The strengthening will be more complete if instead of one, about three cross arches are arranged that rest on intermediate piers, whose arrangement then has a considerable effect on the western end (Fig. 739a).

We can indicate here merely the endless diversity of which these arrangements are capable, and we shall particularly return to it in treating the elevation of the gable end. Meanwhile from what is said will already appear what advantages are to be derived for the treatment of the western part from towers, portals, steps, gallieries and passages.

Since for the oblong form of bay the compartment of the vault thrust acting longitudinally is relatively smaller, then is f found on certain economically constructed works, especially on certain Franciscan churches as in Fritzlar and Treysa, then on those of the carmelites, the so-called brothers' church in Cassel, the western buttresses at the corners of the gable wall are omitted, even when the gaple wall is not made thicker As the thrust at the corner is less than on the continuous wall (Figs. 366, 367), a certain reduction of the abutting mass at the corner is justified (down to 3/4 the thickness elsewhere, p. 136); yet for other reasons men did not like to weaken the corners.

On the churches mentioned the omission of the buttresses may be permissible by other reflections. For especially in Fig. 740 the width of the window is so small, that from the window jamb to the gable wall remains a short length of wall, so that this distance a b may be regarded as an internal buttress, it being assumed that the ashlars and springing of the rib in which passes the thrust of the vault from the arch is so intimately connected with the wall a b, that a displacement of it is impossible. Men appear to have counted on this resistance with great security, for on the church mentioned at Treysa, and further on the transept at Wetter belonging to about the middle of the 13 th century, all buttresses are generally omitted at the corners, where the gable wall was regarded as an internal buttress against the thrust in the direction of the width. But the con-

connection mentioned, and on which depends the security of the construction, alone depends on attaining a length of bonded a ashlars in the direction a b. The adhesive force of the mortar cannot be counted on, since generally all construction is risky that counts on a tensile resistance of masonry.

Hence his boldness has had the worst results on the church in Wetter, indeed in spite of the excellent quality of the mortar, the gable wallu of both transepts have yielded about 10 insa and have entirely separated from the side walls of the transepts. But that in Wetter the consequences mentioned were not caused by the sinking of the foundations results from their excellent condition proved by an investigation made. Fig. 741 shows the plan of the outer bay of one of these transepts with dimensions inserted. The diagonal ribs are semicircles, the c compartments being vaulted with rubble.

But the acceptance of the entire inseparability of the wall led to the churches with two aisles at Fritzlar (Fig. 756) and at Cassel, also to the omission of the buttress on the gable wall corresponding to the thrust of the dividing arch, when men openly counted not only on the resistance of the entire length of the wall, but on the sliding out of that portion of the wall from its plane where nearest to the thrust of the arch. This oversight has been punished in both cases, and the result last mentioned has occurred.

Stair towers at the gable.

The need of access to the attic or the gallery formed in the thickness of the wall led to the necessity of stairs, that could find their place in the thickness of the wall increased for this purpose, as shown below, or in projecting stair towers. But the latter found at the western end a partcularly suitable place, and could be connected with the buttresses in any manner, or where these were wanting, could independently flank the angles, or they might be a continuous transverse connectiong to afford sufficient resistance to replace the buttresses.

The construction of these stair towers will find a fuller t treatment at the proper place, but here will first be explained only the different arrangements of their plans. It was merely so as to be properly combined with the arrangement of the buttress, or to afford in the best way an abutment for the thrust of the vault, and also that the plan was convenient for exit

and entrance. Thus according to Fig. 742 it could adjoin the buttress, even so that the interior space cut into them, and then according to the size of the buttress it was either in t the same plane, projected beyond or receded from it; or it might stand in the angle between them as in Fig. 743; or if the buttress stood diagonally it found its place at the outer end, as on the transepts of the church at Friedberg (Fig. 744); or lays within the nucleus of the buttresses, so that they project from the surfaces of the stair tower (Fig. 745). Likewise could they be combined with the above arrangement and a strengthened gable wall similar to that in Fig. 745, whereby the western buttress is omitted.

The arrangement of such a stair turret may bring with it, t that the intended space for the window in the bay concerned suffered a restriction. In such cases either the width of the window can be reduced as Fig. 746 shows in plan, even so that the arrangement elsewhere of triple or larger windows here becomes single or double as in the western bay of the church in Friedberg, or the window concerned has entirely the same form as the others, so that the stair turret covers a portion of it as shown in elevation in Fig. 747. The last arrangement particularly deserves the preference if the window must occupy the entire space between the buttresses as on the cathedral of Cologne.

It is also to be note, that an anxious care for symmetry and parallelism in such plans is least in place, and while it injures the access and suitability in many cases, the picturesque effect of the whole is reduced. Then the latter may even be secured if only one stair turret is arranged, just as the direct fulfilment of the purpose on simpler conditions. Even on such works that give no evidence of economical construction in other respects, as for example the now ruined church of the monastery of Obin in the Lausitz, is found this arrangement. More monumental indeed is the effect of the western end, if at each angle is found such a turret flanking the structure, as on the S. Chapelle in Paris, and it then approximates the ground form of the double western towers peculiar to the greater churches. But such transfers and such happy effects can be won, yet certain dangerous germs of caprice, and are better avoided in our time, where the strictest adherence to the well understood purpose

is the first requirement.

The size of such stair towers must be in harmony with the dimensions of the whole, but are still arranged according to the purpose, which requires as a minimum a clear width of about 1.5 m, which increases in larger works to about twice this size, as in the stair towers attached to the towers of the cathedral of Paris.

The thickness of the wall is according to the construction, as the tower exists for itself or must resist a thrust acting on it. In the first case and especially with the polygonal form of the exterior, which causes a considerable strengthening of the corners with the round interior, even with the continued transverse connection made by the steps, a very small thickness suffices. Thus on the church of S. Maria in Marburg is found a hexagonal stair tower where the thickness of the wall is but 6 ins. at the middle of the sides.

Such stair towers are sometimes built inside, as in the south transept of S. Severi in Erfurt and the western part of S. Maclou in Rouen. Then then serve exclusively to make accessible the rood screen or some other gallery, yet as a rule owe their origin to a later alteration. Likewise are sometimes found straight stairs with landings ascending in the interior, as in the cathedral of Rouen and in simpler form in the church of the monastery of Haina.

In the western gable wall is generally found an entrance. A Also here must the dimensions harmonize with those of the whole, and first of all must be avoided excessive size, when on the other hand the need already lixes a minimum. For the various designs of portals, reference is made to the section concerned.

Combination of the choir with a wider nave.

The triumphal arch.

The simplest separation between choir and nave in churches with single aisle is made by a greater width of the latter. T The choir polygon extended by one or more rectangular bays then opens by the so-called triumphal arch a b into the nave, whose eastern cross wall serves as an abutment for this arch.

The symbolic meaning of this arch expressed by the name is, that it forms the entrance to the place where the triumph of Christ over death is celebrated. Aside from this significance, which prescribes for the arch found here a certain distinction

in size and form, the strengthening is necessary for several reasons in structural respects. Thus the width c d must oppose the thrust of the rib c e, and the same width in the development of the arch forms the abutment for the thrust of the separate courses of the compartment, at at least when such is lacking, bears the part of the wall up to beneath the arch dividing the nave. Therefore if one thinks as shown in Fig. 749, there stands at a a single round and a cross rib extends from a to b, then to attain the purposes mentioned, also to turn ribs from a and b to c and also over the sides a d, etc., either smaller side arches are found, or the compartments rest on the corresponding parts of the wall in horizontal lines according to the mode of a tunnel vault. In any case must such an arrangement have the advantage, that makes closer the otherwise loose connection between choir and nave, and unites the vaults of both parts in one system. If then a gable wall terminates the nave at the east, against which the roof of the choir abuts, then there must be turned above the vaults the arch supporting the gable wall, like the dividing arches of many late Gothic churches.

More simple than the treatment in Fig. 749 is still the arrangement of a cross arch from a to b (Fig. 748), whose width as well as that of the pier at a depends on the direction of the diagonal rib in the adjacent bay of the choir vault.

Choir ending in a half decagon.

Fig. 748 also shows the choir ending in a half decagon. The peculiarity of this form in regard to the plan of the system of vaults has been explained above. The thickness of the wall and pier could be the same as in the choir with a half octagon, except that in this case is necessary an enlargement of the p pier standing before t, since the adjacent bay by the direction of the rib C r transfers almost the entire weight of its vault to this rib and the cross rib, therefore exerting a far greater thrust, than was the case in the octagonal choir ending.

In Fig. 748 two parallel bays are added to the choir with the same length of sides as for the polygon. But this equality will be avoided if the choir passes directly into the nave, since then the inequality of the panels between the buttresses, that results from the greater width of the bays of the nave, better expresses the actual relations of the whole.

However carefully men thought in mediaeval works to oppose a

corresponding resistance and even to those directions of vault thrusts resulting from certain abnormal plans, and did not aven fear certain irregularities, as shown by the church at Immenhaus near Cassel. Here the choir is wider than the middle aisle, and the springing of its ribs is higher. In Fig. 750 a b indicates the face of the south side of the choir, m o the middle aisle and so the south side aisle, whose vaultinm and dividing arches of wide span therefore have not found the necessary abutment at c in the thickness of the pier supporting the triumphal arch. Hence beneath the beginning of the diagonal rib of the choir is arranged an internal buttress a b d e. On the other hand to resist the thrust of the choir vault at a, the upper thickness a f of the wall suffices on account of the small length of the bay.

The triumphal arch may rest on projecting piers extending f from the ground or corbelled piers, or be corbelled below its springing line, or finalln according to the later method extend between the faces of the choir walls. Put the last arrangement has the disadvantage, that the triumphal arch and the adjacent side arches of the choir vaults become excentric.

To the entire arrangement of unequal widths of choir and nave belongs an uncommon flexibility, that is particularly suited to limeted requirements and means. It widens the room for the community, leaves the choir as free as possible, and makes prominent a separation in its equally advantageous for the ethical importance and the picturesque effect. It especially enters into its rights, where limited conditions lead to the square form of the choir, and plan that without this reduction omits all special accenting of the choir, and must generally produce a certain monotony, but which would be avoided by the greatest simplicity.

A rich anf grand example is presented by the already mentioned church of the monastery of Orbin, whose plan shows a choir comprising 5 sides of the octagon extended by a rectangular bay, that opens by the triumphal arch into a nave consisting of 3 bays, whose width is somewhat more than the diagonal of a square described on the width of the choir. There the axis of the choir lies on the extension of the nave.

Addition to width at one side.

The last arrangement is sometimes found changed, so that the

added width is made only at one side of the nave, as on the Minorites' church in Duisburg represented in Fig. 735. Such irregularitees may first be referred to local conditions, as the plane surface of the north side here indicates tha addition of a structure, yet however affords also certain advantages for convenience in use, since then in this case on the wall surface a b is thereby afforded space for the parish altar, for which half this width would not have sufficed, that would have resulted from a continuous axis.

Plan of transverse aisle.

Instead of increasing the width of the nave, the interior may be enlarged by the arrangement of a transverse aisle, that intersects the nave forming a middle aisle before the triumphal arch with the extension of the choir.

The entire ground form results in the simplest way by the development of the six sides of a cube, the eastern being changed into a polygon (Fig. 751), and it first leads to the arrangement of a square or halved cross vaults, which can then be changed into squares of the transepts, so that in the middle of their sides can be assumed a pier, from which extends a rib in the form of a half arch, to the crown of the vault, so that the vault is divided into 7 parts as on the transepts of the church at Wetzlar, and further by the arrangement of intermediate ribs in the middle square (Fig. 66).

Just as the arrangement of oblong cross vaults comprises in a sense an emancipation from the sjuare form, so will its application to the cross-shaped church will lead to extending the middle square to east and west by a varying number of oblong bays, likewise adding on the north and south one or more bays. The proportions of the different bays may then be the same or different, according to whether the entire ground form or the single bay is made the basis, so that in the first case the proportions of the bay result from the subdivision of the whole, in the other from the addition of bays. In Fig. 752 is assumed the first system.

As a rule the middle bay is enclosed by stronger ribs corresponding to the triumphal arch. If they are here required with less certainty by the construction, they are always of great utility. They offer to the rather unequal stresses in the course of the compartments a safe abutment, whoce thus expresses that

the greater length of the middle square contrasted with lesser ones of the other bays seems to demand a more definite evidence for it. They further afford to the construction over the vault, thus first for the roof or a central tower the required basis, a necessity that can only be expressed in the interior indeed, if the vaults of the middle square are raised above the others, as in the interior of the tower or roof, as in S. M.clou in R Rouen. On the magnitude of the loading therefore depends the dimensions of the arch and of the wall piers strengthening the angles and supporting them.

If in Fig. 752 the width of the arch is made equal to the t thickness of the walls and the arch is constructed with two concentric layers, then the angle pier is built accordingly, whose plan is represented in Fig. 752a, while a b c in the same Fig. shows the arrangement of the round. With a richer form in which for each rib and each layer in the great dividing arches is arranged a separate round, there results the plan represented in Fig. 752b, where a b c is again that of the other rounds. The considerable projections arising in this case are reduced by the corbelling of the outermost parts, thus here the rounds, while the rectangular nucleus either extends from the ground or rests on a column, or may be itself corbelled, or further be assuming a different form of the nucleus, that of a circle or arc, from which the rounds may be corbelled.

The entire plan of the cross church has the advantage over the widening of the nave shown in Fig. 748, of a more organic and united development, the effect in both interior and exterior is richer and more varied. There the ground form itself presents already in a happier way the abutment of the thrust of the middle vault of wide span, while the side walls of the transepts themselves aid in placing the buttresses, and thus make possible the addition of a central tower without special strengthening.

Geometrical relations in dimensions of the plan. Ratio of a abutment to width of span.

Men have often attempted to discover from tradition and measurements definite geometrical relations in the parts of old buildings in plan and elevation, and desire to imagine in them the secrets of the master.

The repetition of equal or similar parts, the constant regular

laying off of lengths, as well as many geometrical divisions that may be derived from the regular hexagon or octagon, from the ratio of the side of the square to its diagonal, etc., may contribute much to make clear and expressive the impression of an art work, and is sufficiently known and escaped the lod masters just as little as the modern. Men have even believed in the middle ages and especially in the late Gothic, that such obtaining of dimensions was practised with diligence.(Further on this see the later systems of Geometrical Proportion).

But the desire to conclude from this, that an entire architectural work in general and detail was restricted within an ever recurring web of circles, is rather risky for even the l later works, but for the creations of the early time contradict their own evidence. Just as the art of the time reaches its noble bloom, that like no other is it free from the restraint of patterns, and yet created the work from its internal nature with powerful strength from case to case.

Width of the abutment according to the rules of experience.

There come into consideration geometrical relations on account not only of the architectural expression, but also in reference to statical requirements, especially in the relation between span of the vault and the thickness of the wall or pier, which by its importance comes into the foreground. We h have then accustomed ourselves in daily practice of vaulting to fix the width of the abutment as a fraction of the span ((for example, 1/3, 1/4, etc.), and it is natural to establish similar values from experience also for vaults of churches, except that here the relations are less simple. So long as the results of statics are not available for the practician or are not sufficiently convenient, there must serve as substitutes in f fact for such starting points, as modern masters have therefore justly held of sufficient importance to establish suitable rules. Some of the most useful are as follows.

Hoffstadt developed in his Gothic A B C the dimensions of w walls and buttresses on the ground of some manuscripts belonging to the latest period from the choir polygon, where he assmed for the thickness of the wall and width of the buttress 1/10 of the clear width of the choir, and for the projection of the buttress from the face of the wall the diagonal of a

square constructed with this dimension. (In Lacker's instructions. See the collected writings of A. Reichensperger, Leipzig. This projection is made twice the thickness). The total width of the buttress was made by Hoffstadt 1/4 (more exactly 0.2414) of the span.

2. Véollet-le-Duc gives in his Dictionary of Architecture ((IV, p. 63) a method apparently employed in the 16 th century, according to which three equal parts were laid off in the arch (R S = (M = M T, Fig. 753) and the distance of the point of division from the vertical erected at the end, thus M N gives the width of the abutment, which is to be laid off outward at T. For the semicircle this amounts to 1/4 the span, for the pointed arch according to its steepness, to 2/9, 1/5 to 1/6. As a limit of the application the height of the abutment is designated as 1 1/2 the span.

3. Hase introduces a similar but more complete method. He determines the width of the buttress likewise by dividing the cross section of the vault in three parts (Figs. 753, 753a), but then for each 4 1/2 m height of abutment adds 15 cm to this. If the buttress of this width consists of heavy natural stone, it might support a vault of light cut stone or strong bricks, but if it be of ordinary bricks, it would suffice for a vault of light bricks. These dimensions are suitable for churches of one aisle if the wall aids somewhat; for a church with three aisles (proportions of width of nave about 2 to 1), then are ample for the stress in the middle aisle as a basis; in any c case they also suffice for the external buttress that receives the flying buttress of the middle aisle. Rectangular bays are assumed with sides in the ratio of about 3 : 3. If the bays a are more nearly square, the abutment is to be correspondingly strengthened.

4. In the earlier editions of this manual is finally given a definite construction first for choir vaults, that takes the thickness of the vault into consideration (Fig. 754). The rib arches over O A will be turned as revolved at A C in the plan, the depth of the rib and the vault lying there is added as A A_1, so as to form the greater revolved arch A_1C_1. At the bisecting point B of this is drawn a tangent to cut the ground line at D. Then the length A D is the width of this buttress. It gives for the semicircle 1/5 to 1/4 the span, notably less for pointed

arches according to their rise, for high pointed arches (rise over 2/3) the method can no longer be applied, since the abutment would be too narrow. The thickness of the buttress and of the wall can be determined by a similar proportion as in Hoffstadt's construction.

The width of the buttress found thus for the choir ending is also assumed to be sufficient for the straight extension of t the choir, it being assumed that the length of bay (b c in Fig. 755) is not much greater than the side of the polygon. Indeed the bays b and c must receive a greater part of the vault than the pier a of the choir, but thereby they have the advantage that they receive the thrust of the side arch, while it falls at a in the direction of the pier and a resultant is borne on the buttress. For longer bays, especially if square, a strengthening of the abutment is necessary.

For long bays is recommended a strengthening for the wall exposed to bending outward, and if the thickness of the wall is to be made in proportion to the length of bay, the ratio of 1 : 6 up to 1 : 8 may be assumed as an average.

If the given rules are compared, there is found a tolerably great harmony among them. Testing them by comparison with old works or by static calculations, it is recognized that for conditions not too unfavorable they suffice very well. But as their originator expresses with great decision, they must serve only as approximate starting points, and must frequently experience very considerable alterations in special cases. As the best of the given methods must be designated the third of C. W. Hase. If we should also add a fifth rule on the ground of static investigations (see above), that would be the following, allied to Hase's rule.

Rule based on static investigations.

5. With the average rise of the vault A B in Fig. 753a (lying between the base line and the keystone) is constructed a pointed arch (or semicircle) and it is divided in three equal parts according to the method of Fig. 753, to obtain the width of the buttress (M N in Fig. 753). Instead of this may be assumed directly for the simicircle 1/4 of the span, for a low pointed arch (rise about 2/3) 2/9 span and for a higher pointed arch (to 60° or with rise of 5/6) 1/5 to 1/6 of the span. To this is added 5 cm for each m in height of the abutment below the

springing of the vault. The abutments of small vaults under a about 5 m span require a further addition of 20 to 30 cm.

Buttresses determined thus and executed in heavy natural stone can easily support light vaults of like material (for example sandstone compartments 15 to 20 cm thick); with execution in bricks of average weight can they receive compartments of 12 cm of ordinary and not too heavy brcies, which must be made 3/4 to 1 brick thick for a span of over 8 or 10 m. For vaults of porous bricks or pumice stone the brick abutments c can be made about 5 per cent narrower and for cut stone abutments about 10 to 15 per cent less.

Assuming square bays which without the aid of the wall are supported by buttresses of the usual form (thickness between 1/2 and 1/3 of the total width at base and slight diminutions upward, about an average inclination of 1 in 20). If the bays are rectangles, according as the length of the rectangle is little or more varied from the square, occurs a reduction of the projection of the pier of ? to 15 per cent. If the moderately perforated wall substantially aids, a further reduction of about 10 per cent or more is permissible.

For churches with one or two aisles the application of this rwle is very simple, the span is taken as a basis, to be measured between the faces of the side arches (not in the clear between the projections). For three-aisled churches it depends on the stability of the middle piers and the transfer of the thrust over the side aisles (see Figs. 350 to 355), whether the buttress is determined according to the span of the middle aisle or to the span intermediate between the middle and side aisles. To determine the abutment only according to the side aisle is seldom allowable.

For braced basilicas with not too flat an inclination, light flying buttresses are the prescribed means applied for strengthening the supporting piers of the flying buttresses, if the span of the middle aisle anf also the height of the abutment are considered. Yet for these important piers such rules should be relied on too much, but always the resultant of the thrust should be obtained, when the weight of the pier etc. is combined with the thrust of the flying buttress (in accurate construction being at most equal to the thrust of the vault increased by a part of the wind pressure acting on the other side. See

p. 165 .od also . section of the basilica.

The correct determination of the abutment is indeed to be regarded as the most important question in all theory of mediaeval construction. Errors in this point are very dangerous on both sides; excessive dimensions increase the usually to low estimated cost, insufficient dimensions not only endanger the duration of the building but also human lives.

If one desires to take into account all the many circumstances, such as the rise, form and thickness of vaults, weight of building materials of vaults and abutments, form and relative heights of the latter, special additional loads of vaults and walls, wind etc.; properly in consideration, the best rules c can no longer suffice, it is then either a trained feeling for construction, or where this is left in the lurch, the calculation of the data. Both are indeed not so very different from each other, what is termed feeling is nothing more than experience based on a reasonable judgment of the most important things in question, the static investigations presuppose just the same logical judgment, that is aided in the less clearly visible points by further aids (theoretical considerations).

Just in the constructions here examined it depends far more on correct basal assumptions, and on the more or less accurate execution of the calculations, simplification and approximation of the latter, that makes the final result a few per cent in error, do not injure the building like large errors in the basal assumptions.

It seemed indicated by the importance of the matter to insert an entire section (p. 122 to 170) in this nev edition of this manual on the relatio of the pier and buttress, and the very simply executed determination of their dimensions. How differently the abutment may result according to circumstances will be shown by a glance at Tables II to IV (p. 150 to 152), the data there will even exhibit still greater variations, if the Tables were extended to other cases, for example the common r relation of wall and buttress, the effects of additional loads on the vaults or abutments.

If the dimensions of the abutments of historical examples are collected, this diversity founded in the nature of the matter rudely appears, and aside from exceptional forms, the thickness of solid walls without piers varies between 1/7 to 1/4 (mostly

1/5 to 1/6), the width of the buttresses between 1/7 to 1/2(m (mostly 1/4 to 1/3), and the thickness of the wall between the buttresses between 1/6 to about 1/14 (mostly 1/8 to 1/10) of the clear span of the vault.

2. Churches with two Aisles.

General plan.

The arrangement of the singleAisled church within certain l limits is connected with the span of the vaults. Indeed certain works of the kind are of unusually wide span, like the cathedral of Alby and the Dominican church of ghent, th.t measure about 19 and 16 m between the wall piers, as then would be possible the erection of vaults in structural respects over still greater widths. But the advantages of such a construction are very doubtful. The extremely important increase in height thereby required increases the volume of the interior in a way m making it difficult to fill the interior by vocal or instrumental means, makes the greater cost of erection, and demands enhanced richness of architectural and decoative treatment to overcome the chilly effect of the width. Thus it goes with excessively wide streets and broad squares on which the most pompous buildings can yet produce no effect. The frequently mentioned church of the monastery of Oybin measures 10.8 m in the nave and must represent about the makimum advisable for a single-aisled plan, beyond which the division in several aisles and first into two appears more suitable.

Plans with two aisles exhibit exceptional forms aside from one of the two following systems.

According to one the choir continues the main aisle with the same breadth, which is adjoined by a narrower side aisle at one side; according to the other both aisles are equal and are separated by a middle row of piers, whose axis falls in the extension of the choir.

Side aisle at one side.

The first plan is found exclusively in the churches of the mendicant orders, is especially common in the provinces of Hesse, on the churches of the Franciscans at Fritzlar (Fig. 756), at Treysa, the church of the Carmelites (brothers) at Cassel.

If already limited space may have contributed to the adoption of this arrangement, as in the places mentioned may be indicated by the lack of windows in the wall of the main aisle,

yet in many restorations are seen peculiar advantages for the preaching that occurred therein, that the pulpit received a location on the entirely closed wall and opposite the open aisles, particularly favorable in respect to acoustics.

The closed wall surface will then be animated by the arrangement of the interior, by hall piers connected by arches, whose purpose is to avoid the obstruction of the buttress externally. On the Franciscan church in Fritzlar, whose plan is shown by Fig. 756, between the piers with openings for this purpose is placed a gallery at the north side.

If the added building does not have the entire height of the principal aisle, as would be the case in cloisters, then above the junction of its roof the buttresses were allowed to project externally as on the Minorites' church in Duisburg (Fig. 735), and thereby the effect of the plain surface of the wall became more varied, since to support the projection of the upper projecting wall must again be turned archer in the interior.

Two similar aisles.

When in regard to the side aisle the entire arrangement coincides with the church of three aisles, the second exhibits the plan with the middle row of piers, also the axial connection of the choir with a hall substantially comes back to that shown in Fig. 748, except that the width of the hall is here divided into two aisles.

In the Organ for Christian Art (9 th year, No. 19), the advantages of this plan are emphasized, that even consist in this, that the reduced spans of the vaults facilitate their construction, much smaller heights, require less thickness of walls and buttresses, thereby producing no insignificant economy in cost, while at the same time the middle row of piers, for which only minimum dimensions are necessary produces no difficulty in execution worthy of consideration, but thereby the picturesque effect of the interior is enhanced in itself and by its connection with the vaulting system of the choir, and at the same t time produces an advantageous division of the interior with a middle passage. The arrangement of the latter then allows the pier to extend to the ground free from the seats avoided with difficulty, so that the entire system was established as particularly applicable to ordinary needs.

The ratio of the width of the nave to that of the choir can

vary, so that the width of the choir varies between the widths of one and two aisles.

As different solutions of the added choir may be mentioned the parish church at Paierbach in lower Austria, whose choir is moved sidewise toward the middle, the little Romanesque cemetery church at Schönna in the Tyrol, which has a semicircular apse before each of the two aisles (also see S. Nicolas' church in Soest, the church at Girkhausen, etc.), and the side building of the parish church at Enns (Note), whose choir occupies the entire width of both aisles, but is divided in three parts by four columns set in a square. Moreover the numerous churches with two aisles, that are scattered over nearly all provinces of northwest Europe and Esthonia, offer ever new and varied solutions.

Note. Also see three in Atlas of ecclesiastical monuments in the Austrian capital.

Dimensions of walls and piers.

External wall.

The thickness of the outer walls and buttresses depends only on the thrust of one aisle, and therefore it is to be determined just as for similar churches with one aisle and equal span of vaults as on p. 148 and 273, thus for half the internal width. At most the wind pressure on the greater roof surfaces of churches with two aisles demands an increase in certain cases.

Middle piers.

The dimensions of the middle piers depend on whether these only support the vaults, or also receive a part of the load of the roof. If the variations of loading are neglected, then the thrust of the vaults neutralize each other for equal widths of aisles and piers. Then the piers are only affected by the vertical load resting on them to crush them, whereby only a small section is required, which is easily found by calculation.

For example if on the pier a in Fig. 759 there meet four square vaults of 7 m span, then the surface of the vaults v x y x rests on the pier, that has an area in plan of 7 × 7 = 49 sq. m, and assuming a unit weight of 450 kil per sq m (see Table on p. 13, column Vb), 49 × 450 = 22050 kil load on the pier. If the pier consists of bricks laid on lime mortar with an allowable pressure of 7 kil per sq. cm, then the area of the pier = 22050 divided by 7 = 3150 sq. cm, consequently there would be

required a round pier of 63 cm diameter.

If the pier consists of ordinary limestone or sandstone, for which is allowed 16 kil per sq. cm, then is needed an area of only $\frac{22050}{16}$ = 1378 sq. cm, for which is calculated a diameter of 42 cm. At the lower part of the pier must be added its own weight to the loading, and thereby the pressure is smowhat increased, therefore to the calculated diameters of 63 or 42 cm must be increased according to the height of the pier. Otherwise the pressures assumed in the calculation of 7 kil for bricks and of 16 for cut stone are to be regarded as very moderate for good construction and good materials.

What small dimensions are made possible by the use of still stronger materials are shown by the granite columns of the Brief chapel in Lübeck, and Artushof in Danzig and the limestone columns of the refectory of S. Martin des pres at Paris. Thus the old works exhibit in all their parts the most accurate consideration of all conditions of statics and of the strength of materials. It would have been childish for an architect of those times to make a pier larger than necessary. In many modern works have men sought to produce a certain effect of earnestness, strength and dignity, sometimes even by the use of excessive dimensions of piers, permitting themselves to rise above such considerations by the feeling for free art. In all cases the way is singular and the effect frequently differs from that intended.

With the dimensions found above agree approximately those of the church in Bornhofen (Fig. 758), where the diameter of the pier measures 50 cm for 5.71 m width of aisles. There the distance between piers is certainly less than the width of the aisle, but the piers are still loaded by the framework of the roof. On the contrary in Namedy the width of the aisle amounts to 3.53 m, the distance between piers in the clear is 4.42 m. With reference to the greater load thereby shown, the diameter of the pier is 38 cm.

For very slender proportions it can be recommended to provide by walls on the cross arches a certain transverse stiffening of the external walls (see the statements respecting this on p. 165 to 169). A similar stiffening lengthwise would be executed over the arch separating the aisles.

Walls over cross and dividing arches.

Such extra walls especially come into consideration, if the roof construction partly rests on the middle piers. If the distance between the piers is not greater than the distances between the main trusses of the roof, then the middle post of the roof will stand exactly on the middle of the pier, that is to have a wall above sufficiently high, that the cross and necessarily also the dividing arches may have a certain stiffness. It is then to be considered that upper walls that do not extend to the ridge above steep pointed arches must rise obliquely to the crown ., so that the latter may not be restricted in height.

When with wide spacing of the piers the distances between t the trusses would be too great, then in the middle between each two piers is inserted another truss, whose supports must stand exactly on the crown of the dividing arch, and in no case load the spandrel of the arch unequally. In this case the wall on the dividing arch must naturally be carried above the crowns; that it may not be too heavy, it is made at most 1 1/2 or 2 b bricks thick, and openings may even be left in the proper places.

The middle supports of the roof will transfer a part of the thrust of the wind, which has to be met by strengthening the middle pier or by strengthening the external walls by stiff cross arches and walls (see p. 165). That the upper walls increase the load on the middle pier and the thrust on the external walls must be properly considered.

Junction of choir and aisles.

The greatest difficulty arises for plans with two aisles from the organic connection desired between the choir and the aisles. To continue this division by the aid of the dividing middle s supports to the triumphal arch presents for most cases an unsatisfactory solution. It is found in the little church at Uezküll on the Duna built about 1200 (the oldest Baltic province. Fig. 747).

If this division of the triumphal arch is to be avoided, then it is necessary to divert the cross rib from the last pier from this direction to one, that will find its support on the triumphal arch itself or on its side piers. This purpose can be attained in different ways, the choice of these being determined by the conditions of the plan.

Triangular bay before the triumphal arch.

1. The chevet form is shown by the church at Bornhofen (Fig.

758). Here the dividing arch divides before the eastern pier into two arches a b and a c. Thus are formed three bays before the triumphal arch, one taking the form of a trinagle and two that of a trapezoid. The diversity of the vaulting bays thus produced may lead to a form of the eastern pier differing from the others. For it increases both the number of the ribs meeting on this pier as well as the area of the vaults loading them, which is enclosed by the figure d e f g h in Fig. 758. This increase of the load will first lead to a strengthening of the pier in question, which with regard to the great number of ribs and of their different directions can be obtained by an addition of a round on the eastern side.

Likewise at the points b and c on which at least a dividing arch and two dividing ribs meet, there is either added to the piers of the triumphal arch, or these piers may themselves receive a form suited to receive these different arches.

Since further the plan of the vault at this place corresponds to that shown in Fig. 741, a strengthened triumphal arch is unnecessary, and therefore in Bornhofen it is replaced by a cross rib.

The ribs meet against the triumphal arch.

2. In Fig. 759 the bays are square and the widths of the aisles equals that of the choir, so that the rib a b from its c crown b can be divided into two b c and b d extending down to the piers of the triumphal arch. The diagonal rib e f would then continue from f to the intersection with the rib b c at g on the same arch, but from the crown e of the triumphal arch must rise in an arch like the h f g i and form over e h a side arch, so that the system of ribs will assume about the form shown in Fig. 759a in perspective. Thus the junction at one side for the ribs g e and k e with the triumphal arch makes it necessary to strengthen it.

3. Allied to that just mentioned is the arrangement in the church of Namedy as shown by the plan in Fig. 760. But variations from it result by the ratio of the width of the chapel to that of the nave and consist in this, that the ribs b c and b d into which divide the dividing arch a b do not reach the piers of the triumphal arch, but adjoin its sides at a height determined by the line of the arch as shown in the cross section of Fig. 760a, so that over c e and d f the side arches over c e

and d f assume an arch line rising from the point f to d, which in a way results from the intersection of the swelled line of the compartment with the surface of the wall, which gives the entire arrangement almost the stamp of an expedient.

Great influence have these different forms of plan on the elevation. For while in Fig. 759 the equal spans of the arches in the choir and nave prescribe equal heights for them, the unequal spans in Namedy produce a greater height of the arch in the choir, hence with an equal height of the crowns is a lower one of the springing line (Fig. 760a). According to the arrangement of Bornhofen on the other hand, the continuity of the system of vaults leads to an equal height of springing lines in choir and nave, therefore either to a drpressed form of the arch in the choir as in Fig. 758a, or to a greater height of its crown.

Junction with the western wall.

At the west the dividing arch in the simplest case rests on the gable wall, indeed either as in Figs. 758 and 760 on a corbel placed over the middle doorway or on a round extending to the ground. The last arrangement would then lead to two doorways, which are then either placed at the middle of the aisles, or could be moved nearer to the middle pier, while the former either shows a continuous strengthening of the western wall w with regard to the thrust of the dividing arch or a buttress is placed on the arch over the doorway, and therefore requires a corresponding projection of the jambs of the doorway from t the gable wall as shown in Fig. 761.

But further the system of vaults might also join the western wall in the same way as at the choir and with a triangular bay, and this arrangement could be connected in a suitable way with the western tower. The same system then leads in its application of the longer sides to the resolution of the entire area of the plan into triangular vaulting bays (Fig. 762).

The execution of the vault in the areas a b c d remaining at the angles etc., allows the most varied arrangements, the nearest of which consists in this, that the sides a b and b c inclose the vault by two half side arches, or the triangle a b c is separated by the rib a c from the triangle a c d, and each of these triangles receives its separate system of ribs.

Likewise is shown by Fig. 764, from a to c a cross arch can

be turmed below the springing of the rib instead of a rib, on which then rests a wall extending in the same direction, so that on the exterior from the right corner b is formed a transition to the obliquely placed side a c. In all these cases c could be omitted the buttress at b. Yet this would be necessary when the bay a b c d is vaulted as a square, and the diagonal rib is turned from d to b.

Further differences would result according to the system of ribs (p. 28), or by the arrangement of a net vault.

Thus further the arrangement of triangular bays could be limited to the eastern and western bays and otherwise be connected with the rectangular bay (Fig. 763).

Halls of secular buildings.

It is in the nature of the matter, that the arrangements shown may be applied in entirely the same manner to the erection of the different halls serving for secular purposes, indeed w that by correct understanding of the manifold needs to which they must correspond, there must even result many different f forms. Magnificent examples of this kind are found in many places. Here belong the great refectory of the castle at Marienburg, the hall of the Artushof at Danzig, and the new school in Prague, a great number of the most diverse monastery interiors in Haina, Maulbronn, the refectory of S. Martin des pres at P Paris, as well as the existing and numerous hospitals in France, so many examples of which are given by Verdier's work, so frequently mentioned. Not all rooms given have two aisles, but the structural advantages before represented are also based only on equal spans of the different aisles, so that they make possible small dimensions of piers also in the plans of hall churches with approximately equal widths of aisles, like the Wiesen church in Soest, and the nave of Erfurt cathedral.

For a moderate size of interiors results the plan of a middle pier, which again in regard to the form of the pier, as well as for the plan of the system of vaults, is capable of an endless variety and may be adapted to the most diverse purposes of rooms, both retaining the simple cross vault, whose bays assume a form corresponding to the shape of the room; as with a and richer system of ribs. For the latter mode of treatment are given sufficient starting points in what has just been said of churches with two aisles, according to which the arrangements

may easily be made in irregular interiors.

As an exampleof a particularly graceful form of this kind we give also in Figs. 765 and 766 the plan and cross section of the chapter hall of the Monastery of Eberbach-on-Rhine, whose style is indeed far from the nobler forms of early Gothic, but the rich and bold effect of the 16 ribs rising from the middle pier is made apparent. As Fig. 7-6a shows, those of the latter which enclose the three triangular bays are larger and are profiled differently from the diagonal ribs subdividing them.

3. Plans of Churches with three or more Aisles.

General proportions of the different parts.

Churches with three aisles first differ in whether a transverse aisle is arranged, or whether the side aisles accompany the middle aisle to the beginning of the choir, and further according to the proportions of the widths of the aisles to each other and to the length of bays.

Square bays.

As already represented on p. 8, the difficulty of vaulting rectangular bays in the Romanesque period led unwillingly to the construction of uniform division in bays according to the mode of Fig. 767, II, but rather instead of these to make for each square middle bay two square side bays of half size as in the mode of Fig. 767, I, When the vaulting of the rectangle offered no further mystery, the uniform division of bays came to the front, although a particular charm was not wanting to the square division with intermediate piers retained in many early Gothic works. The proportion of the width of the middle aisle to those of the side aisles then is 2 to 1, yet small variations occur according to the locations of piers and the faces of the wall, as indicated in Fig. 768.

In the left half are assumed the intersections of the different axes as centres of the wall piers found according to the shape of the detached piers, so that the part which on the former determines the width of the dividing arch, on the latter gives that of the window wall, while the part of the body of the pier remaining within the window wall forms the rounds g h i.

In the right half of the same Fig. on the other hand is placed at k the round of the dividing rib,and the direction of the sama as axes of the diagonal ribs m n in the side aisle is assumed, by which the wall is set farther toward the exterior.

At o is then placed a larger round for the dividing arch o p, and at t, r, etc. are smaller ones for the cross ribs, so that the width of the side aisle between the rounds is greater than on the other side. Still more would this be enlarged, if in t the intersections of the axes in the side aisles are placed only single larger rounds, or even if the members were only corbellod out above. From this it follows first, that the proportions in widths just given as fundamental for the entire construction are a basis without being too absolute.

However the basis of a geometrical system, like the squares arranged beside each other in Fig. 768, is not to be taken too abuolutely. Thus the first variation from it results in the same Fig. by increasing the crossing piers and the dividing arches enclosing the middle square beyond the cboss ribs, while the clear distances between piers remain equal.

Rectangular bays.

When the equal division in bays was continued by the use of oblong bays in the aisles, the proportions of the three distances between piers, widths of side and middle aisles, could be varied in manifold ways, by which either in the middle or side aisles or in both resulted rectangular bays (Fig. 767, II, III, IV).

In some early works is even expressed the proportion 1 : 1 : 2, resulting from the division in squares. With almost complete accuracy is found this in the church of S. Elisabeth at Marburg. In the church at Haina the proportion of the distance between piers to the widths of side aisles from axes of piers to the face of the wall measures 1 : 1, while the doubled distance goes from e to u in Fig. 768. In the church at Frankenberg is the proportion 15:16:29, in that at Wetter is 1:1 to the face of the wall, but where it is to be noted, that in the plan the inner buttress is set farther outward; the same distance then extends from the middle of the pier to that of the bay. In S. L Laurentius at Alnweiler the proportion of the distance between centres of piers to the distance to the external face of the wall is 1:1, and the width of the aisles between axes is determined by the diagonal of the square described thereby. In the church at Friedberg the proportion of the distance between piers to that of the side aisle measured to the middle of the wall is 1:1, and the diagonal of this width extends from c to

u, referring to Fig. 768.

In the minster at Freiburg the diagonal of the distance between piers extends to the middle of the thickness of the walll and the diagonal of one bay of the side aisle measured between the middle of the piers gives the width of the nave. A similar ratio is also containeg by the cathedral of Regensburg. In the cathedral of Rouen the three distances are approximately as 5.5:1 .In all works mentioned are employed the most varied relations of the three distances, but there is a more or less decided predominance of the width of the middle aisle, which in Rouen is more than twice the width of the side aisle, while in others occurs an increasing equality of the three measures.

In the Kreutz church at Breslau, and Wiesen church at Soest, the church at Volksmarsen, the church at Immenhausen, the proportion of the distance between piers to the width of the middle aisle is approximately 1:1, the square bays are produced, whilh the widths of the side aisles increase from half this length to the diagonal of the half. In the choir of the church of S. Sebaldus at Nuremburg all three distances approximate e each other, while in the nave of the cathedral at Erfurt the widths of the side aisles predominate, which then approximate the distance between piers and the decreasing width of the middle aisle. Accordingly even all possible profortions are found, The choice of them depends on the system of construction adopted and aids in determining the character of the work.

' Choir and middle aisle.

The arrangement of the choir dominates the whole in the simplest as well as the most complex arrangements. First the width of the choir equals that of the middle aisle. Yet this equality can already be varied, according as the inner face of t the wall of the choir gives the axis of the piers of the aisle, like the left half in Fig. 759, or the dividing arch forms the direct continuation of the thickness of the wall or of the window arches as shown by the other half of the same Fig. The last arrangement becomes necessary for the arrangement of an elevated middle aisle. Decided variations in width of choir from t that of the middle aisle are found to be caused by special conditions as in Erfurt, while the aisle joining the choir structure at the west is joined by towers dating from an earlier t time, so that the space remaining between them, which corresponds

to about half the choir gives the measure of the middle aisle.

Transverse aisle.

The width of the transepts according to the nearest scheme equals that of the middle aisle. Meanwhile are also found numerous exceptions from this. Thus theeir width in Erfurt is determined by that of the side aisles. In the cathedral at Regensburg this remains about half the width of the piers less than that of the middle aisle. Thus the cathedral of Rheims has a width of the three aisles of the transepts that equals that of the three aisles of the nave, but the side aisles of the former are wider and therefore the middle aisle is narrower, while in Chartres the side aisles of the transepts are narrower than t those of the nave. All such variation from the normal arrangement find their explanation partly in local conditions of the entire space, partly in the system of the entire plan. But they are nowise isolated in the works mentioned, but require substantially different dimensions. Thus for example in Chartres t the widths of the side aisles of the nave gives the distances between piers in the transepts. In the church at Friedberg the width of the transepts equals the distance between piers, so that these are only expressed by the greater depth of the vaulting bays adjoining the middle square.

Number of bays.

The number of vault bays depends on the relative length of the entire church, the length taken by the choir, and the proportions that the bay must have to the system assumed.

Generally it is in the principle of Gothic church architecture, that the length shall dominate the width, and that the greater length is produced rather by the number of bays than by enlarging them.

Distance between piers.

In Catholic churches by the close placing of the piers is a more expressed separation of the aisles for the needs of the worship, more favorable for the services at the same time at different altars. Such must be the case less in Protestant churches, whose direct need requires a wide area connected with a choir. Yet one should also take care there to consider the visibility of the altar from all seats like the galleries in the theatre. The arrangement of piers is a structural necessity in every wide interior, particularly if vaulted that can be av-

avoided only by the greatest sacrifices in material respects, as by excessive height, if the whole is not to fall into an impossible flatness. Therefore one may go so far that the design of churches with a single aisle, as reason permits, or prefer wider spacing and piers with several aisles. Executed works show that the widest play is afforded here; in merely obtaining a wide and unbroken interior, as opposed to the present Catholic form of architecture, the endeavor is to be made that this form of building may also be an esthetic and an ecclesiastical one.

Eastern termination of the side aisles.

This will be simplest by the transverse aisle, or when such is wanting, by straight walls flush with the triumphal arch, which then may be opened by windows.

Rectangular side choirs.

If such side altars are arranged, these find their most appropriate place at these eastern walls, and then will be separated by the altar steps from the area allotted to the congregation, and therefore in a sense form a projecting side choir. It is accordingly next to extend the ending of the side aisles beyond the triumphal arch by one or two bays eastward, thus f first arranging a rectangular side choir, that is separated f from the high choir by walls between the piers a b in Fig. 770.

This termination is either complete, when the walls extend up to the cross arch a b, or they reach only a certain height corresponding a bout to the height of the window sill, above which the arched openings a b either remain open or can be divided by mullions and tracery. The church of S. Blasien in Mühlhausen, whose plan of the choir anf transverse aisle represented in Fig. 770 shows such a treatment, where the wall a b has the height of about 12 ft. The connection with the high choir will be more complete, if the arched openings extend to the f floor as in S. Stephen's in Vienna. Meanwhile to indicate at least a separation, an arrangement may be found here like that where the first bays of the cathedral of Meaux are separated by the choir aisle, consisting in that the pier under the proper dividing arches are connected by cross arches, on which rests the arched tracery forming the upper opening. Fig. 771 exhibits the system of this arrangement in perspective. The arrangement of the plan of Fig. 770 could then exist just as

well without the transverse aisle, and then the bays eastward from the transverse aisle would represent only a continuation of the side aisles, just as here they intersect the transverse aisle.

Round or polygonal side choir.

Meanwhile Romanesque art had already adopted the plan of semicircular side apses at the places concerned, which then passed into the polygonal form in Gothic art and allowed the most varied treatment. In the simplest cases these are five sides of the octagon or extended by a rectangular bay, and adjoin t the walls of the high choir.

Between the eastern ending of the side choirs and the nearest buttress of the choir resulted an interval, that remained ofen, or if size permitted, it could serve for the arrangement of a stair tower (left half of Fig. 772). But with small dimensions of the whole this space was too small, even inaccessible itself and it is then better either to wall up the angle or extend t the east wall of the side to the face of the choir buttress, or rather to form an extension of it, whereby according to the proportions of the whole the sides of the polygon falling in the length may be longer than the others, just as such a form of the polygon itself on the high choir is found, as on the cathedral of Regensburg.

The triangle a d b in Fig. 773 may also remain open and thereby by means of a rib turned from a to b, or according to the resulting shape it forms a partial rectangle with the side e f of the octagon. The last arrangement however makes difficult the plan of an eastern window, whose arch will either be excentric against the side arch or must assume the entire width f d. On the intersection of the walls dividing the choir is true what was said above, only the arches concerned and according to the scale of the side ab of the polygon or of the corresponding rib are to be limited to the span b h, or are to be turned so low that the rib a b can pass over them. Fig. 773a.

Another form of the side choir results, if instead of the s side h i in Fig. 773 the diagonal d i of the bay concerned becomes the base of the polygon, so that the sides of the polygon project beyond the face of the side aisles or rather beyond the point i; right half of Fig. 772. Such an arrangement is found on the church of S. Katherine at Oppenheim so that it

rests on the diagonal of the half hexagon. The same arrangement can be formed with any polygon, and according to its choice t the east window can be placed in the axis of the side aisle. Yet is to be mentioned the plan of a side choir for a high choir, as such is found on the Wiesen church at Soest (Fig. 774). Here the choir formed of 7 sides of the decagon has two side choirs formed of 5 sides of the decagon.

Side choirs with transepts.

The need of determining the width of the side choirs by that of the side aisles is less compulsory if a transept is arranged, whose vaulting plan either has no connection with that of the side aisle, or consists of a greater number of bays. In t the first case the side choir could be placed at the middle of the vault of the transept, in the last case being arranged on a bay of it, so that between the side and high choirs remains an open space.

With greater length of the transept there are sometimes found several side choirs at its eastern wall, which may be formed as polygonal as in Frankfort, or rectangular as in the cathedral at Erfurt. Those last mentioned occupy the entire length of the northern transept, and are so divided that on each bay meet two separated by a pier, and which with less depth are covered by cross vaults, but remain without windows. The arrangement of rectangular side choirs side by side is especially peculiar to Cistercian churches.

Church with three aisles and without transepts.

In Fig. 772 is given the plan of a simple three-aisled church, whose nave for sake of simplicity is divided in but two bays. The choir consists of 5 sides of the octagon and is extended by a rectangular bay at whose sides lie side apses.

The side choir at the left is likewise drawn with 5 sides of the octagon, the angle between it and the nearest buttress is utilized by the plan of a winding stairs, which requires so much space, that its clear circular opening possibly at no place cuts beyond the middle line of the thickness of the wall and also remains a little distant from the middle of the buttress

At the right side is shown an obliquely placed choir polygon, whose base is placed in the direction u w, and not as would h have seemed more natural in the direction s v, for in the last case the buttress would have been weakened too much on the first

side of the polygon.

As the left side of Fig. shows, a sacristy can be added to the side choir as a low structure, or have any other place on the choir.

The bays of the aisles are assumed to be rectangles in the middle of squares in the side aisles. The round pier with 4 rounds is made so large in this case, that its plan is circumscribed by a square formed by the width of the dividing arch. (The members of the vault develop from it as previously mentioned on Fig. 427). Over the last piers of the choir intersect the dividing and triumphal arches, and these piers can be strengthened accordingly, or receive 4 rounds as in the Fig. For the development of the members of the vault from the choir piers, Figs 772a and 772b give two solutions.

For completion,xx the middle tower is attached to the western end, whose breadth extends to the outsides of the dividing arches, the thickness of its walls may equal a fourth of its width. The external square of the tower projects from the face of the western wall according to an arrangement not rare, so that a cross arch extends from x to y, with a width equal to the w wall of the church. The reason for this plan is generally more on the forms of the towers will be given below.

According as the interior of the tower serves as a vestibule or an extension nf the middle aisle, the entrance doorway lies in the eastern or western wall of the tower.

Any possible side entrances can be in the axes of the side aisles in the western wall, or at about the middle on the north or south side, or lie at both places according to the size of the whole. A careful observance of symmehry, so that for a side entrance at one side a similar one must be opposite at the other, is here least appropriate. The location of the doorways is arranged according to the course of those entering, and ends of the streets, and therefore they are omitted or made smaller on such sides from which few or no persons are expected.

Dimensions of walls of choirs.

The thickness of the walls depends on the nature of the vaults, the heights, and generally on the entire development of t the cross section; see above the more definite statements alone under Abutments. If one desires to have a rule of thumb, it may be assumed, that the dividing arches in basilicas of aver-

average height as well as the clearstory walls borne by them are bout as thick as the walls of a single-aisled church of l like span, and further that the external walls of the side aisles according to the width of the latter, are determined rather by the span if the vaults of the middle aisle, and also a about equal the dividing arches. To make a general statement concerning the buttresses is always somewhat risky with the very varied development of cross sections of churches. (See the rules of construction of single-aisled churches on p. 273 and the widths of buttresses on p. 122 etc.). The same are true for the dimensions of crossing and middle piers.

The sides of the pier endings have the same thickness as the walls of the aisles, but much thinner walls can be given to t the low side apses. Yet if here attention also is paid to the support of the roof framework or the formation of the window jambsto make the walls very thick, at least the buttresses can be much reduced or be entirely omitted as on the Wiesen church at Soest.

3. Arrangement of plans of churches with three or more aisles

Five-aisled churches.

The enrichment of plans of choirs by aisles and chevets (p. 298) leads quite early in the great cathedrals to five aisles in the eastern half. If these are all extended beyond the transepts to the western end, thus originates the proper five-aisled church. But there is also found a five-aisled nave connected with the arrangement of a single choir, as on the S. Maria church at Mühlhausen and Se Severi at Erfurt.

Concerning the development in height and the connected function of the heights of piers separating the side aisles may be distinguished three systems.

1. The side aisles have equal heights and the row of piers supports only the vaults and also a part of the roof load. This case occurs when with a high middle aisle the flying buttresses extend over the side aisles in a single arch, as on the cathedral of Paris and the minster of Ulm. The importance of the intermediate pier corresponds to those of churches with two aisles ((see them), if the spans of the aisles are equal so that the thrusts are neutralized, and then the dimensions of the pier can be made quite small, being dependent only on the vertical loading.

Thus in S. Severi's church at Erfurt the ratio of the size of this intermediate pier to the width of the side aisle between axes of piers = 1:10. In S. Maria at Mühlhausen they are greater, but still the piers are substantially weaker than the main piers, about in the proportion of the side to the diagonal, and moreover it appears to have originally differed from the present one, and these intermediate piers seem to have been i intended or built for the heavy roof loading. A particularly small proportion of dimensions is stoll exhibited by the row of piers later added to the side aisles of the minster of Ulm.

2. the side aisles likewise have equal heights, but the piers have additional loads, since the buttresses are in double spans from the clearstory walls to the intermediate piers on that f row of piers and thence are turned farther to the external buttresses.

3. There is found a reduction in height from the middle of the adjacent side aisle and although from that to the outer s side aisle. Like that over the middle dividing arches, there rises over those between the side aisles an externally visible wall, that at the height of the junction of the roof has a triforium and over this a clearstory. The thrust of the vaults of the inner side aisle is conducted by special flying buttresses to the buttresses standing on the outer walls.

The plan with side aisles of equal heights is the usual one and is found in Cologne, Paris, and in plans at Amiens, Chartres and Rheims, where the parallel elongation becomes five-aisled by the system of chapels. The graduated or stepped heights are carried out in the cathedral at Bourges, and is applied to the proportions of the choir chapels and aisle in Beauvais and S. Quentin, but in a more prosaic form on the cathedral of Milan and other Italian works.

It would be useless to undertake an accurate comparison of the effect of side aisles of equal and of stepped heights. Both are properly developed from correct principles, and if the effect of the latter is more surprising, especially of the outer triforium and the windows of the middle aisle are seen through the dividing arches, they afford a particularly rich and varied view, when this arrangement appears as the proper result of an elevated middle aisle, on the other hand by the equally high side aisles is formed a combination of the basilica and the h

hall church, and adopts the advantages of the latter an the m more free and airy form, which the vaults of the side aisles acquire.

The separate parts of the five-aisled plan are so nearly allied to those of the three-aisled church, that then have a common treatment with those in the Chapters on choir endings, pl plans of towers etc.

Polygonal plans of aisles.

In the Early Christian and Byzantine periods of art there c came into the most magnificent use, as shown in the minster at Aix-la-Chapelle, S. Vitale and many other works in the East a and West, the central form for the church proper as already almost dropped in the Romanesque period with the exception of s some Italian churches, until at the boundary of the beginning Gothic a new and more developed system of construction finds a corresponding expression in the exceptional forms of S. Gereon in Cologne.

It is striking that with the further development of Gothic art it disappeared, with the exception of little chapels, and this is chiefly to be explained, by that the actual proportion between choir and nave was reversed in a manner, and a predominant importance was assigned to the latter. Thus such a concentric ground form requires the accenting of the centre, and produces that already by the great effect of the ribs rising to the middle keystone, but this even disturbs the united effect of the principal object and thus splits the line of vision. This effect is to be compared to that of a form where the principal group is contrasted with a side group of equal importance, or to a perspective at the same angle on two streets of equal importance, But to make the direction toward a centre diminant, were it possible as in a circus to arrange a radial treatment or to assume the believers to be in a concentric movement. This disadvantage could indeed be obviated by the arrangement of t the choir, but the conflict no less exists in the nature of the whole. Then the arrangement of each important need for room requires besides colossal dimensions particularly in height, or the provision of a concentric aisle; therefore it could be transferred from this form with advantage to the cross plan with side aisles or to any rectangular form. Fig. 775 exhibits such a transformation of a polygonal church into a cross church with

equal area and length.

But in smaller dimensions the polygonal form must yet have certain special advantages, that may be comprised in these, t that it permits an organic development of a greater width of aisle from the width of the choir, and so produces a certain relation between both, that meanwhile is also formed by the a arrangement of the vaults of a rectangular ground form of the aisle.

The polygonal nave may be spanned either by one vault, or it may be divided according to the number of sides into a certain number of triangular bays that proceed from a middle pier. In the last case the arrangement comes to that shown in Fig. 765, but in the first to the ordinary plan of the choir. Generally with the adoption of an internal row of piers may be easily developed other varied combinations. However all such plans w will demand an imposing height, but better an elevation of the middle space, in order to present externally a pleasing appearan

Just as now the centralization is removed by the choir plan, so can this with advantage also be done by a western front building, that may be given to a vestibule, or is added to the internal area. But it must be termed as reversed, when for the p plan similar on both sides, projecting structures are placed on the sides, that may contain a sacristy or other subordinate room, since for these rooms is required an unsuitable similarity to the choir, as well as on the other hand an opening of these rooms to the inner area entirely removes the character of the polygon and leads to the cross forms.

Better than for an actual church is the polygonal form suited to the plans of all such chapels in which the separation between nave and choir does not occur. Here belong all baptisteries, chapels for the dead, grave chapels, etc., that also especially recur as baptisteries in the periods of mediaeval art

4. Transepts of Churches with several Aisles.

Transepts with one aisle.

Plan of the transepts.

The bays lying next both sides of the middle square and forming the transepts either remain in the line of the side aisles or project beyond it.

The first arrangement is found in the cathedral of Regensburg (Fig. 776), in the cathedral and in S. Severin at Erfurt, and in

essentially lessens the effect of the cross plan, particularly with equal heights of the aisles.

Projecting transepts may either form square bays (Figs. 777, 778), as in the cathedral at Magdeburg or Halberstadt, or may consist of several oblong bays arranged beside each other (Fig. 779). The ending may either be in the usual way with a straight gable wall as at the west end, or it may be made like that of the choir b: a semicircle or polygon, as on S. Elisabeth in Marburg (Fig. 780), the church at Frankenberg, the Kreus church at Breslau, the cathedrals of Noyon and of Soissons.

Form of the crossing piers.

What then concerns the form of the crossing piers, it is nearest as already frequently stated and finally exhibited in the analagous shape of the pier supporting the triumphal arch in Fig. 772b, to develop its form according to the arches resting thereon, also increasing it above the dimensions of the aisle piers. According to the proportions of the cross section may this strengthening be more or less, and in some circumstances it can be entirely omitted. The similarity of the aisle and c crossing piers thus produced is found on many and indeed important works with equal heights of aisles, like the church at W Wetter, S. Maria at Mühlhausen and S. Blasien there, yet here with the modification that the crossing pier has eight and the aisle piers have four rounds. The causes of this similarity, which at the first glance is somewhat surprising, are the following.

The aisle piers must have sufficient dimensions to resist t the excess of thrust of the bays of wider span; Fig. 781 shows part of the church at Wetter; A is the crossing pier, B the a aisle pier, whose dimension must therefore resist the excess of thrust of the vault of the middle aisle acting in the direction B b. Since then the thrust acting in the directions A c and A d on account of the greater area of the middle square are unequally greater than those acting in the contrary directions, then the pier A must be shoved sidewise if not aided by the form of the cross section. Figs. 781a and 781b show the cross section according to B b and A B or B d.

If the dimension of the pier in the first Fig. is made too small, then a fracture occurs at a in the arch of the side aisle and the crown b would rise, so that its fall would follow.

But if in the direction of the cross section in Fig. 781 the same effect results pfrom the excess of thrust the arch of wider span, then the breaking of the dividing arch or the rise of the crown would be prevented by the wall built on it, whose weight is increased by the weight of the roof construction, a and hence even here would be ensured the stability of the pier.

In other words the overload on the crossing pier causes, that the line of support in it becomes more nearly vertical below, but it is to be considered, that the overload must be laid more on the narrow than on the wide arches. (See the effect of a w wall on arches in Example II on p. 157). Thus it is indeed possible, that the much more strongly loaded crossing pier is equally capable of resistance as the aisle pier of the same dimensions. Naturally the pressure on the material in the resisting pier must not exceed the allowable amount.

Corner pier with cross arch ic transept.

When the transepts project beyond the outside of the side a aisles, as in Fig. 782, there results a peculiar condition for the corner pier of the side aisle opposite the crossing pier at A. For this could then only be formed by a portion of the crossing pier, when connected with the opposite pier by an arch similar to the dividing arch. But since for the plan of the latter all grounds are wanting, it is a simple cross rib, and hence under it is only necessary a weaker round d instead of the corresponding portion of the pier. Therefore result various relations represented in Figs. 783 and 785.

In Fig. 785 we have assumed a subdivision of the entire pier according to the arches resting on it with rounds only at the rectangular angles. There is assumed a form of the dividing a arch with two concentric rings, so that the aisle pier a consists of 12 rounds and the crossing pier formed from it has 16. For the opposite corner pier we retain provisionally the same form, and likewise for the wall pier of the side aisle that of the aisle pier a, so that the proper wall is omitted and the width of the dividing arches determines that of the window wall. Accordingly on the corner pier c the two rounds d and e remain without utility. Consequently they must be omitted, while with unchanged positions of the rounds f and g the round for the cross rib is set back at i, so that the form of the wall pier f i g differs from the other subdivision of the piers. In this

way it is possible to place the cross arch h in the middle before the longitudinal axis of the wall.

In the church at Wetter appears the transformation of the c corresponding wall pier d made in a somewhat violent manner in Fig. 781. The ground form is that of the aisle pier and comes to its full development according to the side aisles, where it was to be employed. But according to the transverse aisle the superfluous arc is cut off abruptly by a continuation of the face of the wall, and only one round is placed to receive the cross and diagonal arches.

To a peculiarly ingenious arrangement has this irregularity of the arches led in the church of S. Ouen in Rouen, indeed i in the bay adjoining the middle square, since the transepts a are accompanied by side aisles. For two diagonal ribs extend from the corner piers of this bay, so that the entire bay is divided in five parts, and thus all space between the rounds of these ribs forms a plain surface. Fig. 784 illustrates only the principle of this arrangement without claiming any accuracy, since it was executed from a hasty sketch without measuring. The same principle applied to the location of the rounds in F Fig. 783 would require for both the hexapartite subdivision, or the pentapartite division for the bay of the transept adjoining the middle square, if the side aisles continue beyond the transept.

Most simply is solved the corner pier, if one avoids allowing the cross arch to fall in the extension of the middle of the wall. Then the necessary rounds are placed beside each other, by which the cross arches are moved nearer the middle aisle.

If the window jambs accordingly directly join the rounds, t then they would externally be nearer the corner on the transept, than the windows in the side aisle.

From the various cases mentioned above it appears how imperious is every change in the condition of the arches that makes itself felt, and its effect is only transferred tnd not removed. Thus this is shown in the changed form of the transept rounds in Fig. 783, and in Fig. 784 in the plan of the vault and in Fig. 785 the width of the window pier. Indeed the last irregularity would be scarcely noticed, the window were narrower, b but it essentially exists. Yet it must be noted, that in the fewest cases the windows extendong over the entire surface if

the wall remain open in their full width in the angles of the crossing, but as a rule are rather closed by buttresses or stair towers as on the cathedral of Cologne. In the before mentioned church of S. Ouen is found in this angle a buttress set diagonally. With the exception of stairway towers all such arrangements are only intended to lighten the arrangement of the flying buttresses, as will be shown below. If the thickness of the upper wall is increased by an arch turned between the buttresses over the window arch, it is next to allow the projection of the part k to receive it in the angle of the transept.

Corner pier without cross arch in the transverse aisle.

When the transepts have vault bays projecting sidewise, like those of square form as in Fig. 778, generally no cross arch rests on the corner pier a. With equal height of the aisles, then to limit in height the side arch, excentric from the dividing arch, as Fig. 770a shows, but it produces no tasteful e effect. By a bisecting rib (Fig. 777) the effect can be substantially improved, and one is inclined to seek in this place the principal impulse to the hexapartite vault. The arches require to be inserted only on one side (Fig. 778, right half). Any windows in the side walls of the transverse aisle would also naturally be excentric.

With the arrangement of the lower side aisles the excentric condition of the lower dividing arches will be less disturbing, and also the windows to be inserted above could again be moved to the middle.

Transepts with side aisles.

There result certain special conditions for the form of plan of the crossing piers, as well as of the wall piers found in the angles of the crossing.

Plan of the angle piers.

Fig. 786 exhibits the scheme of such a part of the crossing in which the last named piers a and b shown in Fig. 786a receive form from the number and size of the arches resting thereon. Moreover the depth of the window jamb and of the external arches can also be increased externally in regard to the development of the elevation.

with aisles of equal height the window arches would have to exert a counter thrust against the cross and diagonal arches a and b (Fig. 786a) of the vault, therefore their position and

form are to be arranged accordingly.

That the arrangement of a raised middle aisle be required in a buttress over this corner pier to receive the two flying buttresses turned against the upper pier of the middle aisle, whose middle line meets that of the cross rib a. The simplest m means for strengthening is the arrangement shown in Fig. 786a, where the windows are set back farther or were closed almost to the middle by two buttresses c d, d e standing in the angle. In this case the gutters or roof galleries can be carried above the side aisles around a corbel before the buttress.

Further the thrusts of the two flying buttresses meeting ata right angle would be opposed by a buttress set diagonally, by which the windows are again open. The buttress then has the form dotted in Fig. 786a and the roof gallery continues through i

All the arrangements of the buttersses could be avoided and the thrusts of the flying buttresses from these angle piers be transferred by a second arch to the nearest buttresses m and n in Fig. 786, so that the latter could be met sidewise by the second flying buttress mentioned, and the buttress system intersect at the angle pier a, whereby then the thrust of the nearest window arches increases the resistance of the buttress struck sidewise by a piece of wall remaining beside the window. Such an arrangement is found in the church of S. Ouen in Rouen.

Further difficulties result for the plans of the augle piers enclosing the middle square from the required arrangement of side arches with a raised middle aisle.

Crossing piers with cross arches and without side arches.

Strictly taken the side arches would only be required by the junction of vault compartments to closed wall surfaces, in order to obtain the curved line in which the joining occurs. The latter is produced by the junction of the compartments with cross or dividing arches by the external lines of these. Therefore are they necessary on raised middle and transverse aisles, but not on the side aisles and just as little on the cross arches enclosing the middle square, unless the intended plan of a central tower makes necessary a strengthening of the latter.

Accordingly the crossing piers will be constructed so that a round stands under each arch and three are beneath each dividing arch, and hence results for these the form seen in Fig. 786b, where G G is the cross arch enclosing the middle square

and S S denotes the dividing arch. The sides a b and c d of t the rectangle described around the pier will be greater than the others and have one more round for the dividing arch.

As shown by the Fig. this form brings the disadvantage with itself, that the middle lines of the dividing arch and the cross arches enclosing the middle square separate, as well as a second, that the rounds e and the side arches have the same d dimensions as those of the diagonal ribs f. These disadvantages must lead to retaining the concentric form.

Thus if we reduce the number of rounds on the sides a b and c d by one each, there results the following arrangement.

First the rounds of the side arches can be taken from the d dimensions of the dividing arches, i.e., can rest on the latter. Then if the upper window of the middle aisle fills the entire side of the bay, then can its arches be at the same time side arches (see a in Fig. 846), and also be strengthened by an addition b cut from the edge of the compartment, that takes its development from the compartment. In any case is thereby set back the upper window wall in a manner injurious to the development of the elevation (as will be shown later). It is therefore preferable to allow the rounds of the side arches to project from the face of the dividing arches, and this can be done in two ways. Either these stand on the capitals of the rounds of the diagonal arches enlarged for this purpose, or they are corbelled farther below from the capitals under the dividing arches.

According to what is said here about the form of the regularly subdivided pier will this case be readily solved by the adoption of any different ground form.

Crossing piers for cross and side arches.

If the cross arches enclosing the middle square are to have s side arches, they require five shafts (Fig. 786c). Compared to Fig. 786b, on the sides a b and c d the number of shafts must be increased by one each, and on a c and b d by two each. d Accordingly the dividing arches must have the form given in Fig. 423 from the minsters of Strasburg and of Freiburg, i.e. of three arches next the side aisle and of two next the middle aisle, unless two are entirely superfluous in the side aisles, when no actual rounds are added, which then stand only under the compartment.

. Meanwhile also retaining the usual similar form of dividing arch on both sides, there is constructed a form of crossing pier perfectly corresponding to the parts above it, if the superfluous rounds in the side aisle are replaced by a rectangular increase of the body of the pier, in the angle of which t the round of the diagonal rib finds its place. Fig. 786d shows this last arrangement occurring in the cathedrals of Soissons and Chartres, by which the piers receive a ground form corresponding to the angle of the central tower above as well as to the face of the compartment, and a very useful strengthening.

We have therefore believed more readily that the solving of these conditions must be more accurately developed, than this has not been done everywhere in a happy manner, as in the crossing piers of the cathedral of Rheims the arrangement of such superfluous shafts is not found to be avoided.

5. Plan of the Choir of Churches with more Aisles. Addition of several side choirs.

The ground form of a simply formed principal choir has been described already for the single-aisled church (p. 259 etc.), and likewise the addition of side pier in an eastern or diagonal direction has found an explanation on p. 286 (Figs. 772 to 774). This treats rather the addition at each side of the main choir more as a side chuir, so that a simple arrangement side by side may follow (Fig. 787) or a stepped arrangement with e extended side aisles (Fig. 787a). Still more animated becomes the plan, if the chapels lie diagonally in the angle of a bay of the side aisle intersecting the transverse aisle (Fig. 788).

That the division in bays is the same in the choir and transept, so that there results an equal length for the sides i k, k b and m n, and the bay b k l m is a square, then the chapels be equal to each other and be symmetrical.

If this assumption be incorrect, when k l thus differs from l m, but l m = m n and l k = k i, then will the dimensions of both side choirs be different, but otherwise each can retain its regular form and its direction.

If the last equality disappears, the lines n l and l i form an angle at l, and thereby the directions of the half polygons become different, unless the pier l is moved back in the line i n, when the bay m b k l loses its form as a parallellogram. In a similar way may yet result further irregularities.

With equal heights of aisles and chapels is produced by the endeavor mostly not too great differences in even developed p plans of chapels, since it is usually bossible by proper means to neutralize above the thrusts of the vaults so far as necessary

With raised middle and transverse aisles on the contrary, the necessity to conquer the thrusts of the vaults leads to peculiar forms of flying buttresses or buttresses.

Thus the points k and m exposed to the thrust of vaults are secured by the flying buttersses k l and m l, but the latter abut against a buttress standing at l and separating the chapels, that receives the thrusts of the flying buttresses in the direction of the resultant.

According to the same system would flying buttresses be turned from i to o and from n to p, .od therefore buttresses are also to be placed at the last points. Their forms must then be such, that the windows in the sides of the chapels are not restricted by them. It is therefore preferable to set them back a small distance beyond the points o and p as given at o.

Further these buttresses can be avoided by the arrangement of a detached buttress. At the points o, p and l would then s stand detached piers and receive the flying buttresses, which extend from u to p and further to q in a double arch, also from i to o and then to q, while those from m and k to l must be t turned in the direction of the resultant l q to reach the pier.

But the flying buttresses i o and n p can be avoided if as shown in the right half of Fig. 788, the chapels are so far reduced in size, that the placing of buttresses at the points t and u becomes possible. Thereby the opening between the chapels can be so much increased, that the arrangement of windows in the walls v w and x y again becomes possible. But at the s same time the span of the dividing arch x z becomes smaller, so far as limited by the pier t r. But this eestriction can be avoided by a variation from the regular form of the polygon in the manner, that the face of the buttress forms one side of t the polygon, and the succeeding one abandons its original direction, so that it meets the other in a skilful manner and obtains nearly the same width,as it.

All these expedients become superfluous and all irregularities are avoided, when the plans of the chapels consist of rectangles with added triangular choirendings for the octagon as

shown by Fig. 788. Accordingly the walls of the chapels coincide with the buttresses at a and b, and at most flying buttresses became necessary at the points c and d, which find sufficient abutment in the buttress to be erected at e.

On the other hand the fault is peculiar to the last arrangement, that by an orientated position of the altar, as it is retained in the choir chapels of the French system arranged in a radiating direction, the altar to be placed in the eastern chapel comes to stand against the eastern closing wall, and hence the polygonal ending lies at the side end in a rather superfluous position.

The entire form of the plan passes into the central building with entire decision, if also the same system of choir chapel as the eastern angle is added to the western angles between the nave and transepts, as in the Liebfrauen church at Treves (Fig. 789).

As actual or side chapels may indeed not be regarded these western rooms; we rather have it here with a nave imitating the choir plan, and therefore strike a lack in character, which considerably reduces the worth of the otherwise so thoughtfully arranged form of plan. But generally the striking thought of this appears rather on paper, than makes itself felt by a happy effect in the execution. For finally the difference of a church so formed from one of the ordinary plan (Fig. 768) consists only in this, that the diversity of the different views peculiar to the latter gives place to the monotonyprogressing in the mass, since also the endings of the transepts imitate the high choir. However in the entire arrangement must be recognized the highest stage of the development of the central architecture.

Choir plans with choir aisle.

We have treated in the preceding the different forms of the longitudinal church as well as the central building. The richest development of the church plan is that of the French plans of choirs, but this results from the combination of both systems. This combination is to be understood fully, that it is directly formed by the addition of half a central building to a cross shaped church of three aisles, so that the original bay of the central building becomes the high choir, its aisle is the choir aisle, and its original choir becomes the eastern chapel. In this way we pass in the simplest case to the choir

plan represented in Fig. 790, that is modified according to the number of sides of the polygon.

The choir aisle does not participate in the office celebrated in the high choir, it may receive altars and tombs, but first passes to its particular importance, when it permits access to an eastern chapel or to a chevet of chapels.

Functions of the choir piers.

The high choir is therefore separated from the choir aisle by a series of columns or of piers connected by arches. The functions of the choir piers are more tasteful than those of the nave piers.

If the choir and choir aisle have equal heights, the vault surfaces a b c e f thrust inward and the surfaces a b c i outward, since a b c loads the dividing arches and thus aids in pressing the pier outward. Therefore while in the parallel direction and also in the aisle the excess of the thrust represented by g h k i over that dependent on g k l requires strengthening the piers g and k, the approximate equality of the above surfaces in the polygon allowing this to appear superfluous, a and the dimensions of the pier are exclusively determined by the vertical loading. But even the latter is shown by a glance to be far less than in the aisle, and if e f = l m, amounts to about half the latter.

But that a raised arrangement of the high choir, the thrust of the choir is further transferred by the flying buttresses to the external buttresses, and the dimensions of the pier are determined only by the vertical loading and the need of resistance against the thrust of the choir aisle toward the centre. But this is met by those acting in the sides of the polygon, by dividing arches loaded by masonry, since these extend in the plan in ring form.

Therefore results in both cases the possibility of a considerable reduction of the dimensions of the choir piers from those of the nave piers. But since by the width of the dividing arches as well as by the ribs and formerets of the choir aisle and choir vaults there is required about the same width of the upper area of the pier as in the aisle, then with the smaller dimensions of the choir piers either the capital has a wider projection or the plan of the pier abandons the concentric ground form and with less width must have an undiminished depth.

On the older French works, the churches of Mantes, of S. Leu, the cathedral of Noyon, etc., is necessary an area for setting the upper parts on the slender round piers, whose diameters remain far less than the width of the dividing arches, and only obtained by the bold projection of the square capital, on others like the cathedral of Rouen the projection of the capital is aided by a projecting corbel from its upper edge in bearing the rounds for the choir. Thus by the combination with corbels, as already mentioned in the Section treating of the forms of capitals, there is obtained from the round pier any form required by the entire system.

Plan of the choir piers.

The variation from the round or concentric form of pier occurs, as we have shown in Figs. 425, 426, first by the peculiar arrangement of the rounds. We add further to the examples above that of the choir piers of the cathedral of Beauvais (Fig. 347), where the depth of the form obtained by the pier and rounds is enlarged by the arrangement of a corbel, and thus the picturesque effect of the entire capital is considerably increased.

For here three rounds are placed next the choir aisle but only one next the choir. The capitals of the first have about half the height of the capital of the circular nucleus, the last single round remains without a capital, penetrates the abacus and forms directly above the nucleus a compound corbel, on which again stand three rounds for the diagonal ribs of the choir vault and the arches of the upper window. Therefore the piers in the choir polygon differ from those of the parallel extension of the choir only by the omission on the latter of the rounds beneath the dividing arches.

Since for the present case the arrangement characteristic in the highest degree of that whereby the nucleus of the pier consists of not one, but of two engaged cylinders in depth of smaller and different diameters, which can then have four rounds, two of which conceal the intersection of the cylinders. This arrangement is found in S. Gudule in Brussels, Fig. 791, but in richer development in the cathedral of Cologne. In the cathedral of Coutances both cylinders are further entirely separate from each other, only being connected by a parallel bit of wall, but accordingly are arranged doubled dividing arches, which again are joined together by the projecting stone slabs forming the

floor of the triforium (Fig. 792). We add to this that on the small width of the choir piers, aside from the structural reasons leading to this, already for seeing through toward the choir aisle and the chapels, special weight is to be placed, so much the more the greater the number of sides of the polygon of the choir and accordingly the smaller the sides.

Bays of the choir aisle.

With the longitudinal walls of the eastern chapel then increased the buttress piers standing at the extenaal wall of the choir aisle in the direction of the angle of the polygon (Fig. 790, left), or it formed at the same time this wall, so that the chapel begins with a trapezoidal bay (see Fig. 790, right). In both cases the window is omitted in the first bay. The division into the other bays of the chapel is arranged according to this polygonal ending. Just as well can this eastern chapel also take the square form, likh the cathedral at Auxerre and further as shown on Plates 28 and 32 of the Sketch Book of Vilars de Honnecourt. (Library).

The other polygonal sides of the choir aisle are opened by windows. But here results by the development from the octagon for the sides lying next the chapel a length far exceeding all other arch spans of the choir aisle, which are disadvantageous both for the development of the elevations of the dividing arches as well as for the arrangement of the windows; especially then for the latter, when the entire side is opened by a window, which must have a width exceeding all others.

The nearest means for avoiding this defect lies in the arrangement of a pier in the middle of the side concerned, and of a bisecting rib r extending to the crown of the vault (Fig. 790, right), where again are led those of the two side arches and also those of both windows. For example this arrangement is found at S. Gudule in Brussels. On the arches opening toward the eastern chapel however this arrangement could not well be employed, rather was given the preference to the arrangement of two heavier columns, whereby then the plan of the vault had to assume in the choir aisle as in the chapel the transformation represented in Fig. 793. The placing of these columns with the intention to divide the span of the dividing arches between choir aisle and chapel, is found on certain older French works, as a.

S. Remy in Rheims and Notre Dame in Chalons; but according to the way shown in our Fig. in the cathedral of Auxerre and in yet richer arrangement also in the collegiate church at S. Quentin (Fig. 794).

Another means for attaining the same end lies in avoiding the trapezoidal form of the separate bays of the choir aisle, i.e, in the arrangement of rectangular bays with triangles between them, whereby the polygon of the choir will have twice the number of sides of the choir.

Already the Early Christian central buildings like the minster at Aix-la-Chapelle and the monastery church at Essen, show these in the position reproduced in the left half of Fig. 775, which in certain German works of the 15 th and 16 th centuries has led to the most varied forms of plans of vaults, as in S. Sebald in Nuremberg, the Frauen church in Bamberg (Fig. 804), the Freiberg minster, to which we shall return later. Here further belongs the arrangement occurring in the Liebfrauen church in Worms (Fig. 795), where each trapezoid of the choir aisle is divided into three triangles, so that the side of the high choir forms the base of one triangle and those of the two others lie on the corresponding side of the choir aisle, which is therefore halved by a middle pier.

The side of the polygon of the choir aisle falling in the direction of the length then receives by the position of the cross arch k l (Fig. 790) again a different size, so that all sides of the choir aisle assume a different shape. However all this irregularity is avoided by the last mentioned way of doubling the number of sides of the choir aisle (Fig. 804).

Completed chevet.

By increasing the number of chapels attached to the choir aisle we reach the richest arrangement,

Here are to be distinguished two principal arrangements, according to which the chapels abut against each other and are only separated by the buttresses, or between them is also formed a bay of the choir aisle with a window.

Other very important diversities result from the general plan from the choice of the choir polygon.

Choir ending with five sides of the octagon.

For example if we turn to the first arrangement of chapels abutting against each other in the choir ending from the octagon,

then the before mentioned irregularity in the sides of the enclosing wall (Fig. 790) will also be expressed in the chapels, and even more strongly since the chapels placed at the smaller sides of the octagon receive less projection on account of the smaller width. In this case the elongation of the eastern chapel by one or more rectangular bays is to be preferred to three eastern chapels, so that by the smaller magnitudes of the chapels falling in the longitudinal direction originating accidentally as an irregularity becomes systematic. In this manner is arranged the chevet of S. Ouen in Rouen.

This inequality of the chapels diminishes with the increase in the number of sides of the polygon, and therefore becomes much less for the duodecagon than for the octagon. However it is found to be avoided in the most varied way in the works of the middle ages.

Seven sides of the duodecagon.

The nearest means for producing complete equality consists in abandoning the form of the regular polygon for the outer wall of the choir aisle. In Fig. 796 let a b c d be the duodecagon of a choir with centre at i, a k being the width of the choir aisle, so that there results the form of this by the division in seven parts of the arc described from i with the radius i k. Accordingly the chapel walls certainly become equal, but the direction of the diagonal ribs of the high choir no longer continues in that of the cross arches of the choir aisle and the same as the buttresses, but forms a break with them at the angles of the choir polygon, as for example in the church of the monastery of Altenberg and the cathedral of Chartres.

If this irregularity in direction already really makes necessary only a slight addition in dimensions of the upper choir p piers, it is therefore to be regarded chiefly as incomplete.

This will be entirely avoided by the converse procedure, according to which not the high choir but the wall of the choir a aisle is formed as a regular polygon (Fig. 797), whose base is the entire width of the choir and choir aisle with a centre at C. The first angle d of the polygon then results from the intersection of the radius 1 C by the perpendicular erected at e and thus limiting the width of the high choir, the others from the points of intersection of the radius with the arcs described

from C with the radius C d. Accordingly the choir ending is formed as a regular duodecagon, and only the sides d e falling lengthwise and that offosite have lengths greater than the others. From the construction just indicated , that of the choir of Cologne only varies, that the angles of the duodecagon of the high choir as well as of the choir aisle (Fig. 797),right half) lie in the circumference of the circle described from C with C g a and C f, while the points h and b remain the same. Accordingly the first sides of the polygon have a direction changed from t those of the regular polygon, i.e., they no longer fall in the longitudinal direction but converge toward the East.

The increase in the magnitudes of these sides has other advantages besides the equality of the chapels produced thereby.

First the keystone of the choir vault C falls so far eastuard from the line e h, that the ribs turned to it from the piers e and h receive a direction differing from the extension of the choir ribs d C and k C, but thereby one more suited to offer resistance to the total thrust of the other choir ribs.

The second advantage is connected with the functions of the piers h and e, which have to receive the same number of ribs of the parallel elongation of the choir and of the aisle, therefore receiving dimensions equal to them and exceeding that of the c choir piers. With entire equality of the lengths e d, d l, etc., therefore would the spans of the side arches be regarded as unsuitable and form a disproportion to the larger piers, which is happily avoided by increasing the lengths of the sides.

In the choirs of the cathedrals of Amiens and of Beauvais is found this increase in a lesser proportion than is given in Fig. 797. With the problem of the regular polygon for the choir and choir aisle, thus by moving the centre C toward the base line a b there may be obtained any desired proportion of the first sides of the polygon to the others, equal to each other.

The construction in the cathedral of Amiens is found in Viollet-le-Duc, Dict. Vol. II, p. 332. Accordingly the distance from the base line of the choir polygon to the centre x in Fig. 798 was laid off as a definite measure of 2.5 m (about 1/13 of A B), from this centre a circular arc was struck with the entire width of choir and choir aisle, divided in 7 parts, a radius drawn f from each point of division, thus from points 1 and 6 nearest

the ground line being extended beyond the centre to intersect the base line, the width of the high choir being determined by these intersections N and M.

Further then according to the French construction, the intersections of the before mentioned radii with the circle struck from the centre with the width of the high choir determine the other angles of the choir polygon, and those of the centres of the choir piers.

In this construction contrary to that of Cologne (Fig. 797) the ribs C M and M P (Fig. 798) are equally long in plan, and thereby the choir polygon will become more regular, while on the other hand the advantageous removal of the thrust from the longer ribs C e and C h (Fig. 797) disappears.

If in the plan of Amiens a different rise x is taken as a basis, then xx the given construction would continue the equality of the ribs C M and C P, but the width of the middle aisle would change and indeed a greater x would correspond to a wider, or a smaller x to a narrower middle aisle.

Conversely it would otherwise also be quite possible, first to assume the widths of the aisles and then to determine the corresponding x by trial. By this procedurethe assumption of Viollet-le-Duc would lose its support, that not the builder Renault de Cormont, but already Robert de Luzarches had made the plan of the choir before the erection of the nave. Be that as it may be; in any case must the plan of the choir of Amiens be regarded as masterly.

Five sides of the octagon.

The construction of the choir here developed from the duodecagon or the division of the circle are peculiar to the works of the first size like the three great cathedrals. In more limited proportions the distance of the choir piers from each other would accordingly become too small, and therefore as a rule five sides of the decagon are taken as the choir ending, according to which is shown by Fig. 797, the chapels as well as the bays of the choir aisle without further means of themselwes have equal sizes.

Dimensions of walls and piers.

In the given Figs are deweloped only the skeletons of the forms considered, which in the further execution must receive

the thickness of walls and piers.

For those who adhere to determining the dimensions of the walls and piers not by static standpoints, but according to fixed rules, the following statements may have their place.

In Fig. 797 the widths of the dividing arches are assumed about as great as the thickness of the walls of a single choir, thus perhaps 1/12 to 1/10 of the clear span. The dividing arch consists of two rings according to one of the profiles given in Figs. 422 to 427, and it accordingly determiner the dimensions of the choir piers with reference to the other ribs resting thereon and the rounds. Half the width of the dividing arch can be taken as the width of the cross arches, and the half diagonal of the latter for that of the cross ribs of the vault of the choir aisle, the width of the cross arches is also taken for t the arches turned over the entrances of the chapels, and therefore half of it is laid off at each side of the middle line, accordingly determining in the same way the form of the plan of the supports of these arches, the wall piers with their rounds forming the ends of the walls separating the chapels, with regard to the vault ribs meeting thereon, so that for each rib is arranged a round and the diameter of the nucleus of the pier will about equal the diagonal of the width of the cross rib. The width of the arches separating the chapels from the choir aisle is then to be made only equal to that of the cross arches, if this does not have to bear any walls rising above the roofs of the chapels, but in the last cases it then approaches that of the separating arches, by which the dimensions of the piers must be increased.

The chapels themselves may be formed by five sides of the octagon. They would be separated from each other by the walls placed behind piers 1, 2 and 3, strengthened by the radiating position of the piers. This increased thickness therefore makes possible a very small thickness for the junction with the pier, and the size of the chapels is dependent thereon. The minimum of this thickness will occur when the perpendiculars drawn at the angles of the polygon of the choir aisle to its sides form the internal faces of the wall of the chapels. In Fig. 797 it is better to make the thickness of the junction with the pier equal to the width of the cross arch, so that in the space remaining between the lines 1 m and the rounds n are placed the

rounds for the diagonal ribs and side arches of the chapels. Then the other rounds for the diagonal ribs in the chapels are located according to the regular octagon, the founds for the s side arches are added, and the thickness of the walls of the chapels is made equal to the width of the cross arch, the thickness of the buttresses equal to the diagonal of that measure, and their depth is determined for a simple choir.

The thickness of the great buttresses between the chapels which then have to receive the flying buttresses is determined by the diagonal of the width of the dividing arch of the high choir, and these project about the same distance beyond the ja junction of the walls of the chapel. Accordingly there is given a suitable determination of the width of the chapel buttresses by the circular arc struck from the centre o with radius o p.

The flying buttresses on the choir of the basilica usually receive far less thrust than those of the nave. The high choir vaults exert at the angles of the polygon only a thrust, which is 1/4 or at most 1/2 as great as that of a bay of the middle aisle. For resisting the wind the flying buttress on the choir likewise has less importance, but on the contrary with greater breadth of the windows the side arches intersecting at an obtuse angle produce a resultant outward thrust, which cannot occur at the nave.

Usually the flying buttresses of the choir as well as their buttresses have long not required to be as strong as for the nave. On the other hand one also need not fear too heavy flying buttresses on the choir as much as on the nave, since a great pressure directed inward, that requires in the nave a stiff vault oh a well built cross arch, can be readily received in the continuous polygonal walls. Thereby at most the side arch and its upper wall may be pressed toward the crossing, where a corresponding counter thrust must be found.

Buttresses between chapels.

The small thickness of the chapel walls at the junction with the pier in the cathedrals of Amiens and Beauvais led to the peculiarly spirited arrangement, that the proper buttress that must receive the thrust of the flying buttress, does not begin at the internal face of the side aisle but is set farther out at about g r s t. over the piers in the polygon of the choir

aisle ar set intermediate piers of more concentric plan, that indicate the hexagon on pier 2 extended upward. These last receive directly the flying buttresses and from them are again turned smaller flying buttresses to the proper buttresses g r s t, so that the chapel walls are first loaded there, where they have acquired the necessary strength by their increased thickness.

This arrangement of the buttress system then led further, also to perforate the piece of wall between the chapels by an arched opening, and thus finally produced the arrangement peculiar to the cathedral of Coutances, whereby to the proper buttress are first added the rounds v and w, accordingl: having a greater p projection, and in the angles of the choir aisle the piers become too detached, between which and the buttresses are now found triangular bays and vaults, that connect together the separate chapels and in a sense form a second narrower choir aisle. The right half of Fig. 797 shows this arrangement.

An increased thickness of the walls separating the chapels and also in the dimensions of the piers standing in the angles of the choir aisle therefore becomes necessary, when the buttresses receiving the flying buttresses begin directly from the choir aisle, and hence the little intermediate arches disappear. They are further required if the arrangement by which the walls or the window wall between the buttresses is placed farther outward, so that passages leading through the latter are found, also employed in the choir chapels, as in the cathedral of Rheims.

This strengthening can be obtained either by a reduction of the chapels or by the arrangement of buttresses with parallel sides between the chapels, as in S. Pierre at Louvain, whereby also the ground form of the chapels differs from the regular polygonal shape (Fig. 800), or to the polygonal ending of it is prefixed a trapezoidal bay in a similar way, as already given in regard to the eastern chapel in Fig. 790.

Various forms of chapels.

This increase in the depth of the chapels can also be obtained by the arrangement represented in Fig. 797, either by prefixing a rectangular bay before the polygonal ending or by lengthening the sides of the octagon next the choir aisle beyond the measure resulting from the regular polygonal form. Further everything said concerning the polygonal form of the choir also applies to

the chapels, and each polygon or any irrational division of the circle would form that ending, so far as the sides have a moderate size.

The form according to five sides of the octagon would be nearest to that according to four sides of the hexagon, which is f found in the choir of the Freiburg minster.

The ending in the half polygon, thus according to three sides of the hexagon, five of the decagonwill for the system of ribs require one of the solutions given in Figs. 728, 729, 731.

But a very peculiar forms then lead those shown in Fig. 799, when the chapels consist of the half polygon without a prefixed rectangular bay. In this case it would be desirable to the system of ribs of the prefixed bay of the choir aisle of the choir concerned with that of the polygonal chapel, as shown in Fig. 801, i.e., the keystone lies in the middle of the arch forming the outer polygonal side of the choir aisle, and from the opposite choir piers a and b are turned diagonal ribs to this keystone, whose thrusts hold in equilibrium that of the chapel ribs. In the choir of the cathedral of Soissons is found this arrangement, which thus by its nature only represents an application of the rib system adopted for the high choir to the chapels.

The peculiarity of this arrangement, that the chapels with the adjacent bays of the choir aisle are connected into one vaulted bay, is found in a simplified way again in certain North German works, and indeed in connection with the high choir composed of five sides of the octagon, as on the church of S. Maria in Lübeck (Fig. 80). This system is first distinguished from that of the choir of Soissons in that the space required for the polygonal ending of the chapels has no choir aisle extendind its full width, but the width is reduced, so that strictly speaking the high choir is directly adjoined by the chapels and a passage results only by openings in these separating walls, therefore as Fig. 802 shows, and the side aisle accompanying the parallel extensionof the high choir only a half width. But there the eastern chapel by its parallel extension projects far beyond t the others, which thereby again extends in the proportion of a widening of the choir aisle like a chapel, as then the polygonal parts are less than half the polygon.

The arrangement of such flatter chapels composed of only three

sides of a decagon before the bays of the choir aisle requiring the full width would therefore represent an adjustment of both arrangements, and thus be counted with the arrangements mentioned on p. 300, by which the inconvenient size of the outer sides of the polygon of the choir aisle would be avoided.

As actual chapels with altars placed therein the areas so obtained cannot be employed. Therefore those io the cathedral of S. Quentin the chapels shaped according to the entire octagon project, as Fig. 794 shows, so that the columns standing in the outer polygonal side of the choir aisle become at the same time the angles of the octagon, and between the latter anf the choir aisle remain triangular vault bays. The richness of the entire form is then increased, so that the chapels receive less height than that of the choir aisle, and thus over the dividing arches resting on the columns stands a wall perforated by three double windows. But even in this lies the weakness of the construction, since the chapels by means of the low position of their vaults cannot oppose those of the choir aisle, and hence the vaultsof the ribs r r find no sufficient abutment.

Chevet with intervals.

The second of the arrangementr distinguished above, that according to which the chapels abut against each other, but windows are left between them for direct lighting of the choir aisle is the earlier one. Already in certain Romanesque works like S. Godehard in Hildesheim but more frequently in France, appears the plan of little semicircular chapels or those formed by a greater segment and projecting from the external wall of the choir aisle. In Gothic art the walls of the chapels became buttresses for t the vault ribs producing a further division of the bays of the choir aisle. Accordingly the system of this vault changes. Either is retained the trapezoidal form and the vault triangle next the exterior is divided in three parts by two ribs extending to the keystone (Fig. 803), or the trapezoidal form is reversed, so that the larger side is formed by the distance between the choir piers and the smaller by the chapel walls, these trapezoids being then covered by cross vaults (Fig. 803 b). Between each two such bays are inserted two triangular ones as in the cathedral of Bourges, that however is not of polygonal form but is semicircular. The same arrangement applied to the poly-

polygonal.form would then lead to shaping the polygon of the c choir aisle to thrice the number of the sides of the high choir (Fig. 803 c).

A simplification, the least for the plan, is found in the system of the Early Christian round buildings, whereby to each of the rectangular bays is attached a chapel, and the triangular sides lying between them are opened by windows (Fig.803 d). On the German works mentioned on p. 300, that exhibit this arrangement of the vaults of the choir aisle the high choir is formed according to the octagon. The chapel wall is there sixteensided with equal sides, if the width of the choir aisle equals the d diagonal of the square of the side of the polygon. But the application of this system to the duodecagon in the choir of the cathedral of Le Mans by the inclination resulting from the last polygon for the sides of the rectangles perpendicular to the sides of the polygon, led again to changing the rectangles into trapezoids slightly narrowed externally, which the chapels adjoin, and between which are found the much smalles bases of the triangles opened by windows. An actual simplification of the structural system was obtained in none of the last mentioned ways, since the continuous straight line through buttresses, choir and keystone was lost, and therefore the necessity appeared to produce the resistance to the vaults of the high choir by two flying buttresses from each pier extendind out to the external buttress. But this increase in buttresses and flying buttresses is already injurious, since the principal object, the high choir, is withdrawn from view. Therefore all such arrangements are better suited for ailes of equal heights.

The simplest solution results when to each space between the piers of the high choir corresponds a trapezoidal bay, and then the bay opening into the chapel alternates with that indepently lighted by a window, so that also with a choir ending from the decagon gives three chapels and two bays with windows as on the cathedral of Rouen.

By the before mentioned division of the vaults of the choir aisle into rectangular bays with the triangular ones lying between them (Fig. 803 d) can also be chapels added to the latter. Such a chevet with the doubled number of the sides of the polygon of the high choir as found in the Frauen church in Bamberg, Fig. 804. Here the vaults of the choir aisle rest on corresponding

heads of the buttresses divided inside into moulded wall piers, and the wall opened with windows is placed back in the face of the latter, so that nine rectangular chapels are formed, whose depths are the widths of the buttresses.

The same arrangement, but with richer subdivision of the plan and with polygonal chapels is then found also on the choir of Freiburg minster (Fig. 805), here the high choir has three sides of the hexagon, and accordingly the choir aisle has six sides of the regular duodecagon, but the transition of these forms into another is effected by a net vault. The polygonal sides of the choir aisle are formed of four sides of the hexagon again with net vaults over the chapels, so that they project two of the sixteen sides beyond the remaining buttresses, with an angle in the middle between them. The chapels are then continued also along the parallel sides of the choir aisle between the buttresses to the side towers adjoining the transepts.

The peculiarities of thes plan are shown in an indeed less c correct mathematically, but freer and grander conception of the plan of the chuir of the cathedral of Paris (Fig. 806).

Here is the high choir formed by a raised semicircle, divided by six round piers at equal distances into five parts and surrounded by double side aisles. The choir aisles are separated by great piers set opposite the choir piers and five smaller piers between them, so that to the five spaces of the choir correspond ten in the choir aisle. Their second circle is again surrounded by a third concentric one, formed by six buttresses opposite the heavier piers and two moulded pries between each pair.

Only the western part adjoining the parallel extension is divided by one moulded pier instead of two piers in the divisions of this circle made by the buttresses. Between the six buttresses mentioned then lie the annular chapels belonging to a later rebuilding. The choir is also surrounded by two galleries divided in triangular bays and they indeed correspond to each space between the piers of the choir, three triangles in the first of and five in the second gallery.

According to all systems before mentioned the ground form of the high choir is surrounded by the concentric aisles anf the series of chapels. By the abundant use of triangular bays would be obtained each irrational relation of the ground forms to each

other, i.e., could be solved according to a regular polygon, or according to a choir with five sides of a decagon, square in its geneaal form, or be formed according to an entirely irregular polygon with single or double choir aisle. Such arrangements are indeed not to be sought, yet may seem required in certain cases by local conditions.

Instead of further explanation, we shall refer to two examples indeed belonging first to the last period of Gothic art.

In S. Stephen in Beauvais, the motive of the arrangement of its choir being shown in Fig. 807, the high choir is enclosed by three sides of the hexagon. One of the two side aisles curves around the choir, but the other stops abruptly, so that here results a straight line termination truncated by small oblique sides from which projects only one eastery chapel.

The same ground motive is followed by the plan of S. Germain l'Auxerrois in Paris with only the difference, that all bays of the eastern end open into chapels of certainly very irregular plans, which are kept within the eastery rectilinear termination.

Arrangement of plan between choir and transepts.

According to the simplest arrangement, the chapels form an external projection from the line of the side aisle. Yet as a rule the space between this projection and the transverse aisle is filled, either by the primarily divided or later added continuation of the chapels to the transverse aisle, or by the arrangement of double side aisles to the choir. The continued chapels either have the same polygonal ending as on the choir (Freiburg), or they lie between the buttresses as simple rectangular bays. (Fig. 799, k).

The grandest arrangement is that of doubled side aisles as shown by Fig. 797, found in Germany in Cologne and Altenburg, as well as on the cathedral of Amiens and at Beauvais, also many other French works. These then occur at their sides again before the chapels, so that their eastern buttresses conceal the western window of the latter. Therefore is found as a rule the space resulting between these buttresses and the oblique sides of the polygonal chapels is filled by the plan of a stair tower (Fig. 797), which then is either accessible from the chapel or the eastern bay of the side aisle.

The wall between the last chapel and the side aisle must rec-

receive the side thrust of the chapel ribs o o_1 in Fig. 797. This is so small, that the wall requires no great thickness, s sometimes by filling the corners, and at others the thrust can be opposed by a partial rib k yin the vault of the side aisle.

6. Forms of Plans of Towers.

The purpose of the towers is essentially demonstrative (Note), they are to make known the church afar by the sound of the bells and their tapering shape , and at the same time bring the characteristic peculiarities of the entire form to an enhanced expression.

Note. We leave aside certain recent and more symbolical meanings of towers, because nothing is changed in them from what is here given.

Position of towers.

There follows from the purpose first the requirement of a predominant height, and thus results the second that they shall not be built at random, but at certain main points stand in intimate relation thereto, i.e., rise over certain particularly accented points.

We accordingly have to distinguish:--

1. Towers belonging to the middle aisle.
2. Towers added to the side aisles.

The former find their places:--

a. Over the middle square of the cross shaped churches as central towers.
b. At the western end of the middle aisle.
c. At the north and south ends of the transverse aisle.
d. Over the choir ending.

The second also naturally stand:--

a. Before or on the western bays of the side aisles.
b. Over the end bays of the side aisles accompanying the transverse aisle.
c. Over the eastern bays of the side aisles before the beginning of the choir polygon.
d. In the angles between the nave and transepts over the corresponding bays of the side aisles.

From these result the following naturally occurring cases.

1. The ordinary arrangement of one western tower.
2. That of two towers before the middle of the transepts as on S. Stephen in Vienna.

A combination of these two first arrangements with each other nowhere occurs within our knowledge.

3. The arrangement of a central tower.

A combination of the last with one of the former or with both the former arrangements is found only on works of the transition style, and was formed so that the middle tower surpassed the o others in size, but it then always has the fault that in a rectangular elevation one tower conceals one of the other towers.

4. The arrangement of two western towers.

5. The combination of these with a central tower.

6. The arrangement of six towers at the ends of the nave and transepts in combination with a central tower, as found on the cathedral of Laon and was intended at Rheims.

7. The combination of the last arrangement with two other towers before the beginning of the choir polygon as intended at Chartres.

With the two last arrangements must therefore be combined that of the central tower, so that one is found to dominate over the great number of competing towers.

Central tower.

The arrangement of a central tower, which is more rare in general but is commonly found in France and England, requires in the plan only the strengthening of the crossing piers treated on p. 295, and therefore must be the most economical of all when a transverse aisle exists. Substantially increased will be the effect by small stair towers in the vicinity of the central tower or at the angles of the transepts as on Notre Dame at Dijon.

Tower over the choir.

The arrangement of a tower over the choir ending does not harmonize well with its polygonal form, and is found only over rectagular choirs on certain buildings of the late period, thus in extremely picturesque form on the two aisled church of Niederasphe in upper Hesse. It cannot further be combined with the arrangement of a transverse aisle, since the tower would seem to be removed from over the crossing to the wrong place.

A single western tower.

The western end of the middle aisle offers the only single location existing on the church, if we except the arrangement of

a crossing tower and that last mentioned, and therefore it will combine here a symmetrical form of the whole with the economically preferable single tower. Further the width of the middle aisle offers a great base for the proposed tower and therefore allows a greater development in height than would be possible for one over the narrower side aisles. Herein lie the advantages of the single western tower. On the contrary the disadvantage is peculiar to it, that at least the four of the side facades produce an excessive detached effect; this fault appears strongest on single aisled churches, where the tower conceals the entire gable end. It is reduced in the measure that the tower is enclosed by the side aisles.

For the relation of the tower to the middle aisle to be conceivable, the width of the latter must determine the square of the tower. But since the necessary thickness of the walls of t the tower or the widths of the arches and piers replacing the latter exceeds that of the divided arches of the nave piers, so here is given greater play, within which that determination is to be understood.

Thus the clear width of the tower corresponds to the clear w width of the middle aisle, or the side of the external square of the tower to the width of the middle aisle with the added widths of the piers, or the axes of the piers may fall in the middle thickness of the tower walls, or finally these may limit the external square of the tower. For all the proportions mentioned could' be given a large number of examples.

What then concerns the position of the tower in the longitudinal direction, the usual arrangement is that whereby its entire ground area projects free, and indeed from the internal, or as in Wetter from the external face of the western wall.

The internal area of the tower either, as on Freiberg cathedral, forms an open vestibule and the church portal recedes to the eastern wall of the tower, or it is taken into the church by an arched opening, the portal being placed in the western w wall, a third arrangement would be an enclosed vestibule furnished with doorways at the west and east.

The different developments of these arrangements, according to the height of this lower story of the tower, will be examined with the development of the section and elevation.

The connection with the church is more clearly expressed if at both sides of the tower the side aisles each continue in one bay, so that the tower is built about to the middle, or about as on the church of Frankenberg each of them continue for two bays, so that the western wall of the side aisles is entirely or approximately in the line of the western tower.

Both arrangements last mentioned could be combined with each of the above mentioned uses of the internal area of the tower, but the first could only lead to placing the doorway back in t the middle of the area of the tower, so that half the latter forms the vestibule, but the other half is taken into the interior (Fig. 808). The connection of the latter half with the church will be more complete if it opens sidewise into the adjacent bays of the side aisles, then the eastern angles of the tower being supported by isolated piers as shown in the right half of the same Fig.

If the sides of an entirely included western tower are open, there would result with two bays of the side aisles adjoining the tower a cier standing in the middle of the tower square as shown in the left half of Fig. 809. The omission of this would not harmonize with the remaining system of the tower, and again a dividing rib in the tower vault requiring a pier on the other hand the arrangement of one or more would not harmonize with t the other system of the vaults of the side aisles leads to a b bay adjoining the tower (Fig. 809, right half), or finally it requires a peculiar solution of the vaults of the side aisles corresponding about to Figs. 90 and 90 a, as found in an even more complex way in S. Pierre in Louvain.

Such difficulties are indeed removed, when the system of construction of the entire church is developed from the construction of the tower instead of from the choir. But this reversal of the legitimate proportions contrary to the importance of the whole, as may be easily conceived, introduces en entire series of other faults.

Therefore the arrangement last mentioned permits the entire opening of three sides of the tower into the church, combined with the arrangement of one western tower in a rather violent manner, while it is to be regarded as the most complete solution of the arrangement of two western towers, and in the latter

is made easier by the small area of the ddimensions of the necessary piers.

Towers before the transverse aisle.

Everything just said of western towers similarly applies to the towers placed before the transverse aisle. Other differences would only result here according as the towers directly adjoin the middle crossing square, or are separated therefrom by a bay corresponding to the width of the side aisle. In the first cases the crossing pier becomes at the same time the inner pier of the tower, and the arrangement takes about the form given in Fig. 810.

Two western towers.

The arrangement of two western towers is best suited to the system of the plan and also most favorable to the development of the western side. The relation of the tower square to the side aisle can be the same as the relation of a single western tower to the middle aisle. The limited width of the side aisle causes this arrangement to be the usual one, whereby the clear width of the side aisle agrees with that of the tower, and therefore with the excess of the thickness of its walls projects at one side beyond the outer face of the side aisle, and on the other side narrows the enclosed part of the middle aisle.

Western towers before doubled side aisles.

A further increase of the tower square results thereby, that its middle lines project beyond those of the side aisles, and therefore the towers have a more important projection externally than from the mere thickness of the wall (Fig. 811). The last arrangement was indeed most common and is found in all periods of Gothic art, from the earliest time (cathedral of Noyon) until the end of the 15 th century (S. Martin's church in Cassel). Indeed it includes a certain caprice and cannot go to the extent, that the walls of the side aisles abut against the middle of t the tower square, and therefore the towers have the same size, which is given them by the arrangement of doubled side aisles.

With doubled side aisles, three arrangements are possible for complete connection of them with the church. For the row of piers between the side aisles may continue in the towers, and there lead to the plan of the four vault bays with intermediate piers in the middle of each square side of the tower with a middle pier at the centre of the area as in Cologne cathedral.

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Further this bisection can only go to the intermediate piers of the tower walls, and to avoid the isolated middle column, the internal room of the tower can be spanned by an octagonal cross vault as in the cathedral of Paris. Finally also the bisection of the vaults of the side aisles can be changed into unity by means of a system of triangles before the junction with the tower as in Fig. 812. Likewise a raising of the starting point as in Fig. 90 would be possible.

These different arrangements of the vaults exert a certain influence on the form of the portals of towers. A combination in the mode of Fig. 812 naturally leads to the plan of a portal o opening in the middle. This arrangement is carried out on the cathedral of Paris in the way, that the before mentioned intermediate pier in the middle of the western side of the tower is also the dividing pier of the double doorway of this portal, wherefore in contrast to the otherwise small width of the last pier extends through the entire thickness of the wa,,, while t the arched jambs of the portal project from the face of the wall and extend before the angle buttresses. On the contrary in Cologne cathedral the bisection is made and led to the removal of the portal of the tower to the bay adjoining the middle aisle, while the outer bay adjoining the entrance forms a chapel beside it, that opens to the west by a window.

But generally the arrangement of portals in the side towers is not an absolute rule. For example they are wanting on the c church S. Elisabeth at Marburg, the cathedral in Meissen, the church S. Lorenz in Nuremberg, and they are further lacking on the towers of the side aisles of the transepts of the cattedrals of Laon and of Rheims.

We have already characterized the complete combination of t the internal rooms of these side towers with the aisles as best corresponding to the entire arrangement. Differing arrangements may here avail as exceptions, as the complete combination with the towers of the middle aisle. On many older towers the lower room is entirely enclosed, and also is the rule in north German brick churches. The middle aisle extends between the two towers almost without exception, since the abutments for a vault between the two towers are given in them, and hence the continuation of the middle aisle to the line of the western towers through the entire plan seems required. An omission of this outer bay

of the middle aisle, as found on the western side of Friedberg church according to the original plan (Fig. 813), whereby the towers enclose an uncovered forecoutt a, leads only to saving a small piece of vault, but on the contrary to the loss of a very useful room and to a divided form of western entrance.

Since the side towers of narrow side aisles were frequently made wider, middle piers before wide giddle aisles of single aisled churches may have less than the breadth of the middle aisle in a converse sense (Fig. 814). The wimth can be made as needed, leaving sufficient space for passage in the lower room of the tower.

In such a plan as given in Fig. 814, the junction with the church can be narrower, if the tower is utilized as abutment of vaults by the course of the ribs, where the triangles a b c in Figs. 57 or 58 are vawlted and the buttresses at the anbles bc can be omitted.

By means of corbelling then occurs the possibility of making the lower ground area of the tower rectangular instead of square, and indeed by strengthening the western wall by two buttresses, from which poject at both sides the corbellings supporting the walls of the tower (Fig. 814 a, section). Such forms can finally pass i into the higher corbelled gable here.

Unsymmetrical arrangements.

Since in the preceding all arrangements designated as symmetrical are so only in regard to the western facade, on the contrary becomong unsymmetrical for the north and south sides, then also for the western facade simple works may also depart from symmetry, thereby in many cases producing caterial utility and a very picturesque general effect. Justifying reasons therefore must well be found in local conditions.

Such unsymmetrical plans result when the tower has a position with only a symmetrical effect when doubled, or in small dimensions is placed on the intersection formed by the buttress and the adjeacent wall.

In Germany is indeed generally symmetry is as sacred to the "cultured public" as dogs and cats were to the Egyptianr, and anything opposing it can scarcely be executed.

It appears in England as shown by many modern buildings, that greater freedom is allowed in this respect. Indeed it cannot be denied, that the monumental character is so much diminished by

an unsymmetrical arrangement of the tower as the the picturesque effect gains. Unfortunately the cases are not rare when limited means make only the last attainable.

Walls and piers of towers.

Solid tower walls below.

If we now return to that regular symmetrical arrangement of towers, there then results an essential difference whether the system of construction of towers is calculated on a strengthening of the walls by buttresses extending down to the base or such are lacking. The last arrangement is simplest; the tower square increased by the thickness of the walls projects from t the inner, or as in Wetter from the outside face of the wall of the western facade, and affords the required base for all separate parts extending upward as on the tower of the Frankenberg church (Fig. 815), buttresses already result above the portal story by the offset in the outer face of the wall, without coming in contact with the walls and piers of the church. Even the internal area of the tower could be taken into the church, when the eastern corners would be supported by isolated piers, for which certainly would be required considerable dimensions. But generally hre entire system makes necessary great thickness of the walls, if the tower has a moderate height.

Buttresses carried down externally and internally.

If we now assume the buttresses to extend down to the foundation, the piers must fall in the direction of the divided arches, and it would first produce on an externally projecting tower the conditions shown in Fig. 816.

In the right half of Fig. 816 the tower buttresses project f from the internal side of the western wall as internal buttresses, the dividing arches extend from the buttresses, thus from the points a to the nearest piers, and the spaces between the buttresses and the bays lying next them are spanned by tunnel vaults.

In the left half is then found the arrangement corresponding to the system of the Freiberg minster, whereby the buttresses are placed under the dividing arches, so that only the upper part of their western half is deweloped. If the northeast and southeast buttresses extend from the ground, in both cases the doorway or window opening the western wall must be set farther out of the axis of the side aisle, as occurred in Freiberg in

regard to the western rose window. However this fault would be avoided by strengthening the angle pier d, whereby the tower buttresses could stand on the arches turned from c to d in the left half of Fig. 810.

If we now assume a western tower included between the side aisles as closed walls at both sides, then retaining the system of tower buttresses shown in the left half of Fig. 816 at both sides under the cross arches, as then are at the east beneath the dividing arches or according to the arrangement shown in t the right half are beneath the series of compartme ts, or finally a division into bays is given to the side aisles adjoining the tower, a division entirely different from the others according to that shown in the left half of Fig. 817, i.e. it would in a sense form a transverse structure before the western end of the church, from the middle of which rises the tower.

Both halves of Fig. 817 exhibit the analogous case of the plan of a tower open on three sides. In the right half the nucleus of the eastern pier of the tower is formed by the square of the thickness of the wall, before which projects the buttres extending beneath the arch. Io the left half the system of division in bays about like the arrangement of S. Pierre in Louvain is so changed, tha to it is added as essential elements the t tower piers formed accordinm to the required plans. The shape of the last substantially agrees with that shown in the right half, yet with a considerable width of the tower buttress nearly pruduces a termination of the western bay of the nave, as then the great thickness of this tower pier stamps the arrangements in Figs. 816 and 817 as still incomplete.

In the plans described with buttresses at the sides, the tower fomms an entirely independent whole, which maintains perfect s stability without any aid from the mass of the church. This isolation of the pier would bring the advantage, that the settlement caused by the greater weight of the tower would remain without influence on the construction of the church. Yet this advantage is lost by the bond of the tower masonry with the vault p piers, and therefore to ensure it, the tower piers formed as in Fig. 817 must have the necessary strong piers for receiving the vaults without any bond an separate down to the foundation. But this last arrangement would make impossible the extension of the tower foundations on the side next the church, and thus is not

easily executed.

If according to the first rules of construction the foundations are so dimensioned, that beneath each pier and wall each s square unit if the ground bears only a permissible pressure, e everywhere the same for a yielding soil (p. 189, 146), it is generally unnecessary to count on a greater sinking of the tower walls, indeed for the following reasons. The causes of such wo- ould only be in the greater compression of the joints in the m masonry of the tower by the greater load. But this compression ceases with the complete hardening of the mortar. Since it is now assumed, that between the time in which the masonry of the tower is carried to the height of the walls, and the further construction of this upper part will elapse sufficient time for the hardening of the mortar, then the sinking can only occur in the upper part not connected with the church. (On a yielding s soil the erection can so proceed, that at no time may the pressures under adjacent parts show too great differences.

Reduction of inner tower piers.

But by the loss of independence of the tower are given the means of a considerable reduction of the mass of the eastern tower piers, indeed on the following grounds. It was chiefly t the arrangement of buttresses for the tower that required this inconvenient size. But now the buttress presents a variation from the vertical direction, thus in a way stiffening the tower, then increasing the bearing area of the foundations at the points, where the effect of the load is concentrated, thus at the corners.

But the last purpose may also be attained as a rule by a considerable depth of such tower foundations already of a strong batter, and as for the first, the endeavor would be just as complete if the buttress is entirely separated from the masonry of the tower, and is only connected therewith by arches at different heights, also as with full connection this is broken above each gallery by passages. But to the service given by such isolated buttresses corresponds perfectly the stress imparted to the inner tower piers by the adjacent dividing arches and the walls thereon, and generally by the entire system of the construction of the church. Accordingly for these inner tower piers yet exists only the necessity, that they afford sufficient area for receiving the upper considerably diminished parts extending

above the roof.

With two moderately large western towers, each corresponding to a side aisle, it will suffice to construct the tower and crossing piers with the size of four dividing arches meeting on them with rounds remaining between them for the cross arches.

For more important dimensions of the tower, thus for the arrangement of one western tower or of two corresponding to doubled side aisles, the inner tower piers would be strengthened, and this would be done by the formation of the arches in three layers, so that the plan of the crossing pier would be made as shown in Fig. 786 d.

Farther back was given the plan and internal elevation of the lower part of the tower portion of the collegiate church of Mantes, which in a particularly clear manner shows, how the stability of the inner tower piers is obtained by the connection with adjacent parts of the building.

Dividing arches receive the buttresses.

A further reduction of the mass of the inner tower piers could be obtained within certain limits by placing the buttresses on the dividing arches.

A similar arrangement, the placing of piers on arches, may f first be represented by that given in Fig. 811, produced by side piers projecting beyond the side aisles. For here according to the projection of the tower, the eastern buttress a of the tower closed the window of the bay of the side aisle if carried up f from the ground. Therefore on the cathedral of Rheims broad arches are turned from the angles of the tower square to the nearest buttresses on the side aesle, thus to b in Fig. 811, which strike the side of the latter, on it being set the tower buttress with length extending beyond the crown of the arch. But this arrangement even requires the extreme width of the buttress, to offer resistance to the thrust so much increased by the load.

But we meet an essentially different condition in the internal aisle piers. None of them is sufficiently strong to resist the thrust of the arch increased by the loading, and therefore it only remains, either to strengthen the piers nearest the tower so far, that this thrust ends in them, or to take into account the resistance of the entire series of arches, then strengthening the corner or crossing pier. Thus in both cases must be added to one of the piers mentioned about what could be taken from

the tower pier, so that no real advantage is to be obtained thereby.

However far the reduction of the inner tower pier must go is in certain cases to be based on calculations, allied to those made for the middle pier (p. 153 et seq.). The load must not exceed the allowable limit of compression of the stone, and the line of pressure under the influence of the vaults of the tower and of the aisle must not take adirection too near the outside, and the foundation must be enlarged sufficienltn that the tendency to sinking of the inner piers is no greater than for the outer ones. If these conditions are satisfied and corresponding consideration is devoted in the progress of the construction to the setting of the masonry, then for a suitable building nothing is to be feared for the tower.

The depth of the foundation walls in the ground will be determined by their gradual increase in thickness, by the limit of frost and by any possibility of the removal of earth around them. To carry the foundations of towers into ground of high resistance much lower than the ground walls of a church is generally useless, but is even doubtful in some cirmumstances.

Thickness of walls.

On the thickness of walls and size of piers nothing general may well be stated, since according to the constructive principle of the whole, since this is made according to the height as well as to the execution of the masonry. An enumeration of these proportions on executed works could therefore be really useful only in connection with a representation of the entire construction, and therefore we limit ourselves to the proportions of the tower at Frankenberg as limits for the thickness of the walls of the lower story of a tower,on which no buttresses are found on the lower story, and the thickness of the walls is 8/14 of the internal span, with those of freiberg minster can be contrasted, where the thickness of the walls is 1/8 of the tower square, w while the arrangement of very wide buttresses aids them. On north German brick buildings, partly on account of the smammel strength of the materials, partly for the massive tower forms thereby required, the proportions at Frankenberg are even exceeded, and for example on the towers of the church S. Maria at Lübeck the thickness of the wall is 3/4 of the clear width of the tower.

Connection of towers with stair towers.

With the towers are usually connected stair towers, which even

become necessary, if access to the upper rooms in the towers is not arranged from the attic over the vaults.

We have here chiefly to distinguish between two kinds of plans, first the usual one of stair towers placed before the exterior, and those entirely concealed and more rarely occurring, where the stairway is taken in the thickness of the wall, as in the tower of Frankenberg church (Fig. 815 a).

With the last arrangement is connected a disadvantage, that they weaken the masonry, while the volume about the stairway is reduced about 9/10, if the steps are included. Therefore in regard to construction it is to be justified in all cases, when the mass of the tower walls and pier consist of rubble, so that the cut stone of the steps and enclosing walls must replace the loss in volume by the goodness of the material and the jointing of the masonry.

Yet in a higher degree is it injurious to the artistic expression of the tower. For exactly according to the predominant extent in half the tower will the stairs, that give access to the most important room in the tower, namely the belfry, forms an especially important arrangement for all that do not fear it. This is indeed the same in every building of several stories, but it is here made evident and must be visible externally or internally. But the internally visible location of massive stairs inside the tower room would restrict the tower wall below and the arrangement of the belfry above, also the space required for swinging the bells inconveniently. Therefore it remains most usual to project from the exterior in order to give its character to the tower, which consists in a contrast to the enclosed structures representing pylons and pagodas, in that it has to obtain the largest possible internal space.

But the combination of the smaller stair towers with the great structure also increases the effect of the latter, and lends it a certain picturesque charm, even when the arrangement varies from symmetry, as then in simpler works the arrangement of the stair tower seldom forms the principal ornament of the whole.

The ordinary arrangements of stair towers are the following.

1. Before the middle of the longitudinal side of the tower, either so that the interior lies outside the face of the wall, or that it cuts into that (Fig. 812 at a).

2. In combination with the buttresses (Fig. 811 at a), either

lying against one, or in the external angle between the two set at right angles, or between a buttress and the wall of the aisle. (Fig. 813 at b).

With a richer resolution of the entire tower structure into a system of piers and arches, such as found in the greater cathedrals, such an unsymmetrical arrangement exerts a certain influence on the whole. Thus the stair towers of S. Gudule in Brussels project from the western side of the tower and its external buttresses, thereby limiting the magnitude of this side of the square by their own width. However the same architectural subdivision is carried out on the restricted sides of the towers as in the longitudinal direction, retaining the full size, so that the middle of the architecture of the western facade falls outside the middle line of the square of the tower. The possibility of this arrangement lies in the horizontal termination of the tower lacking a spire, that finds its upper ending in the belfry flanked by stair towers and opened by two openings for sound at each side, but which would be made essentially more difficult by the addition of a spire necessary to the whole.

On the contrary the spire makes the entirely regular division of the entire tower a necessity, in whose system the unsymmetrically placed stair tower enters in an irregular way, as on the towers of Cologne cathedral, on which just these stair towers form one of the most interesting and richest parts.

The arrangement of stair towers in the angle opened between two buttresses at right angles is sometimes found, so that they have the effect of essentially integral parts of the western facade, thus projecting as towers at the outer angles, as on the cathedral of Coutances, on which those buttresses form the side walls of the square stone towers, thus giving an entirely independent form.

Then further may also occur as towers all arrangements given in Figs. 742 to 746.

Massive stairs in the interiors of towers are found in the c church of Ahrweiler (Fig. 818), where one of the two rises only to the tower gallery and the section goes to the upper story of the tower. Others variously connected with the dewelopment of the elevation with stairs extending to the upper stories can be first described in connection with them.

7. Subordinate Buildings of Churches: Internal Arrangements; Rood Lofts.

Sacristies.

The sacristies required by the Christian confessions have led to many peculiarities in modern churches, when impressed by the necessity of symmetry, they are partly placed in false apses, while the church itself must be contend with a rectangular plan, partly accommodated by a corresponding duplicate of the first requirement.

In the conditions of ordinary parish churches, they are satisfied with one sacristy, while on larger churches like cathedrals, two would be required besides various halls.

In regard to plans suitable for these subordinate structures may be distinguished three sorts.

1. In a room belonging to the system of the church, for example in one or more bays of the side aisle accompanying the choir, first in the choir plan with choir aisle and chevet, in the rectangular bays inserted between the chapels and transepts.

2. As directly external additions to the longer sides of the choir or aven to the polygonal ending.

3. As independent buildings connected with the church by a passage, as indicated by dotted lines in Fig. 819.

The first arrangement according to the modern conception, the monumental effect of the whole being injured by the outgrowth, must also be by its nature least suited, so far as it claims excessive justification for the room in question with the church, and prescribes a very inconvenient height and arrangement of t the windows. So far as known to us, it is found only on certain cathedrals in southern France.

The second arrangement predominates by far, corresponding in the simplest way to the direct needs, and executed at the least cost. It is far removed from injuring the external effect of the church, but enhances its picturesque charm, and we could name a series of churches on which the choir arrangements furnished with just such additions form the splendid parts of the whole.

Only the arrangement of the roof presents some difficulties for the limited height of the church.

According to the simplest arrangement the roof of the sacristy joins a continuation of the choir. Indeed the windou of the bay of the choir next the sacristy would be covered, thus causing

a defect, which may be changed to an advantage by the use of mural paintings in the surface thus obtaened. A model arrangement of this kind is shown by the church in Wetter, where the lower part of the wall surface is utilized for placing choir stalls, while the mural painting above is S. Maria crowned by two angels, representing at their feet the foundresses of the convent, and filling the space beneath the side arch.

By the arrangement of an independent gable or hip roof over the sacristy with a gutter between et and the church, that extends before the buttresses of the latter, so that a shed roof again rises to the church walls, the windows of the latter can remain open. But this arrangement by the independence of the r roof leads over to third mentioned above, according to which t the sacristy may take any form and size and not be affected by the buttresses of the church. As mediaeval examples of this kind we mention the sacristy of the cathedral of Amiens, which forms an acute angle with the church by which it is connected by a passage, but further the decagonal addition placed before the eastern side of the S. transept of the cathedral at Soissons, now serving as a sacristy but originally a chapel. Quite particularly does this plan appear correct, where it is necessary to connect a greater number of rooms with the church, then leading to the plan of enclosing a rectangular court, the so-called cloister passage opening from it, which the necessary rooms adjoin.

As true models of this kind at a smaller scale can count the buildings added to the cathedral of Paris and of Amiens mentioned by Viollet-le-Duc, while grand arrangements remain still in rich number in the cloisters of many cathedrals, monasteries and collegiate churches.

Principal parts of the internal equipment.

In Fig. 819 we further indicate tche chief parts of the internal equipment of the church and will here insert the explanation. There belong to this:--

1. The altars placed in the choir, of which the high altar is free and stands at about the centre of the polygon, and the side altars in the east line at the eastern walls of the side choirs, thoseat the right side coming to stand before the angle at a'.

2. The tabernacle b', the little recess about 60 cm wide and 75 cm high, 40 cm deep, closed by a door, which as a rule is in the last bay of the north side, also sometimes is in the northeast

angle of the polygon, or finds its place in the east side of a rectangular choir. Since now a symmetrical arrangement in reference to the whole is impossible, it is superfluous to place it in a certain bay. The interior of the tabernacle must contain a means to protect it from dampness. Before it the everburning lamp finds its place on a metal bracket with a roller for raising and lowering it.

3. The piscina c' in the simplest arrangement being an open niche with a generally corbelled stone basin, usually in the side opposite the tabernacle.

4. The repository d' for the consecrated oil. A closed recess similar to the tabernacle, but smaller.

5. A sedilia e'. A triple seat in a niche in the wall for the celebrant priest and the deacons. The seat as a rule consists of a stone bench not projecting beyond the inner face of the wall, down to which extends the niche. More rarely the niche descends to the floor, so that the seats are placed in it.

The arrangement of such sedilias is also entirely in place in Protestant churches, and would replace the hateful latticed wardrobes that serve as seats for pastors. Where the thickness of the wall is not sufficient, the projection even occurs on the outside of the wall. The minimum height if the niche is fixed at the height of the body.

The place of the pulpit is customary against one of the aisle piers. It can then depend on the magnitude of the church whether it is one of the piers supporting the triumphal arch or is brought forward to one of the middle piers. In single-aisled churches it stands against one of the walls. For such of small width of the choir, as the church at Nieste (Fig. 733), against the very suitable eastern wall of the aisle caused by the difference in widths of the choir and aisle. Entirely nonsensical on the contrary is the usually preferred modern location behind the altar, whereby the speaker is placed at the greatest possible distance from the listeners. This location culminates in the favorite construction in several stories, by which altar, pulpit and organ are combined in one object.

7. The font or baptismal basin also sometimes retains its traditional position in the western bay of the northern side aisle at g', as in the cathedral of S. Martin at Lübeck, between the

western towers or the western bay of the middle aisle. But the last arrangement requires the incessant closing of the doors leading into the bay concerned. The most perfect arrangement accordingly consists in the arrangement of a sepaaate baptismal chapel, which either as in the church S. Nicolai in Hamburg is added in the angle between the tower and the western end of the side aisle, or results from the elongation of the side aisle to the western facade of the tower, or finally a more isolated location connected by a passage with the western part of the church.

8. The organ came from Byzantium and was probably utilized f first for church purposes in the minster of aix-la-Chapelle, then gradually introduced more widely. Since the 13 th century the great churches frequently had two organs, the smaller one on the rood loft, the larger mostly standing in the western part of the nave. On the best mode of its establishment, the middle ages t therefore left us without exact conclusions, since the few remaining ancient organs were added later to the older churches, so that they chiefly came to accommodate themselves to what existed. The different arrangements of them known to us are the following.

In the minster at Strasburg the organ is found above the third bay of the northern side aisle, so that the works are in an organ chamber projecting externally, and the front including the keyboard is placed in a balcony corbelled out from the dividing arch concerned. Likewise in Ulm, Stendal and Dortmund (still p preserved), its place is found in the northern aisle.

In S. Severi at Erfurt is found on the eastern wall of the north transept a corbelled balcony, on which formerly the organ had its place.

In the Lübeck church of S. Maria the organ stands on the vault between the western towers.

The reasons for one or the other place have already been often so fully explained (Note 1), that it is scarcely necessary to add them here. Chiefly must we give the preference to a location nearer the middle of the church as found in Strasburg, in so far that this best corresponds to better hearing, allows the organist a direct view of the altar, and the organ is in its proper and more sidewise location. With aisles of equal height, this arrangement should be somewhat modified, so that the piers of the bay of the side aisle concerned would be spanned by a lower

vault, about as in the galleries at Ahrweiler and Kidrich-a-R. (Note 2). However it was hard to give up the position common in the last centuries at the western end of the middle aisle, partly from habit and partly since the public finds objectionable an unsymmetrical arrangement. With the arrangement of a western tower may then the wind shutters and generally the works of the organ be placed in the interior of the tower and on the lower vault, the so-called front standing on the arch. x y, or i. Before the organ is the arrangement of a gallery required at least for the singers, when the organist has to direct the singing at the same time. In other cases, especially when the precentor exists, this gallery could be separated from the organ, as by placing it in the side aisle in the opposite bay, thus saving the symmetry. Thus is found in S. Severi in Erfurt such a balcony in the S. transept in the same place as the organ gallery. But the balcony must have its place at the west side, where it can be corbelled out for this requires less space, but larger ones should not be separated by piers. With small length of bays, these piers then stand so near the aisle piers, that it would be better to connect the gallery with them and arrange one intermediate pier, to reduce the stress in the arch and the required height. But in any case is to be given preference here to a stone gallery over a wooden one.

Note 1. Reichensperger. Hints, Organ for Christian art, church decoration.

Note 2. In the collegiate church in Wetter is found in the last bay of the s. side aisle before the transept a vault dating from the end of the 15 th or beginning of the 16 th centuries for receiving the organ, whose diagonal and cross arches are pointed and have only 10 ft. in height to the crown.

In the arrangement with double towers the organ comes between them, and if the towers are wanting at the west end, it then stands on the gallery. But it would also be better to arrange a projection and to place the organ in its upper story. But often the arrangement at the west end is to be regarded as a misfortune for the very reason, that the peculiar expression of its clever character is thereby disturbed, and the west end is only one, but the bays of the side aisle are repeated, and therefore an alteration of them by the organ cannot be injurious.

Arrangement of the rood loft.

The rood loft (lettner, lectorium) denotes a gallery for speaking, that originated from the connection with the pulpit (ambo), at the same time it forms a separation between the choir and the nave.

Its place is found either at the beginning of the high choir under the triumphal arch as at Naumburg, Gelnhausen, Wetzlar, Friedberg, Lübeck, etc., or at the western side of the middle square as in S. Elisapeth's at Marburg, or is placed one or more bays westerly as in the monastery churches of Maulbronn and Haina. Its position is determined by the proportion of the size of the choir to the actual one, depending on the special purpose of the church, thus being a particularly great need of space in the monastery church.

Its extent also depends in a certain respect on its position. Under the triumphal arch it therefore extends only for the clear width of the choir, either on the western side of the middle square or it extends on three sides, adding the area of the transepts to the high choir, and continues across the widths of the arches, is sometimes transferred further west and also crosses the three aisles, finally with the richer choir with choir aisle it is inserted between the piers of the high choir, thus continuing the dividing walls to a certain height, and sometimes is perforated.

If we disregard the original form produced by the combination with the two ambos, no example of which is known in Germany, its simplest design is the wall always furnished with openings, before the middle of which and at the west is an altar for the parish service, over the latter being found a balcony for speaking, that meanwhile for acoustic reasons is not to be regarded as a pulpit for the sermon, but is only used for reading the epistles and gospels.

This gallery for speaking must not be placed on the altar slab, as for example was done in Haina in the earlier restoration (Note), so that the clergy step on that, but it must be formed by a balcony at the east side of the rood screen, thus lying behind the altar and opening into the middle aisle by an arch in the middle of the rood screen.

Note. It is supposed that this peculiar arrangement owes its origin to the desire to use this balcony as a pulpit.

As examples we mention the present arrangement imitated from the original in the church of S. Elisabeth in Marburg, as well as the original arrangement at Haina, which we represent in section in Fig. 822.

Far more complete in every respect is the arrangement of the gallery for speaking on a vault covering the before mentioned altar and serving it is a ciborium, extending from the wall of the rood screen to two isolated columns. For example such is d found in the church at Friedberg (Fig. 821, section) and at Gelnhauses (Figs. 820, 820 a).

According to the former an arrangement affording a small height for the balcony for speaking may be in the middle behind the rood screen and requiring stairs, while with high rood screens and the corresponding arrangement of the choir stalls, the location of the steps may be around one of the piers between which the rood screen is built.

By this is further necessary the arrangement of a connecting passage on the upper surface of the wall, and hence a widening of the latter is required by corbelling, which is then continued also on the other side of the gallery, so that this forms at both sides of it open galleries with railings as in Friedberg.

The endeavor to increase the widths of these galleries then leads to placing before these walls arcades, after the style of the arcades under the parapets of the windows in the side aisle, as on the western rood screen at Naumburg, and further to place the colonnades or arcades at a certain distance from the wall, covering this by cross vaults (Fig. 823).

Accordingly the retaining of the canopied projecting balcony for speaking was superfluous, since the entire rood loft formed it. Meanwhile a reminiscence of it is found in the polygonal form (Fig. 820 a), so that the altar finds its place under the middle bay.

In order to limit the view of the altar as little as possible, in most examples known to us the columns have the smallest dimensions, and the stability against the thrusts of the vault is sought by iron anchors, connecting the spans of the vault together not always directly over the capitals, but better at the height where the thrusts of the arches act.

The rear wall opens into the triumphal arch by two doors at

both sides of the altar (Fig. 820 a), and furtter in certain cases, as in the collegiate church at Wetzlar, by a latticed arched opening made over the altar, whhich arrangement however is impossible wherever at iy Gelnhausen, choir stalls are placed on the east side of the rood screen. Over the rood loft is generally placed a great crucifix, whose arrangement differs according to that of the rood loft.

According to that simplest arrangement found in Baina, where the speaking gallery opens to the aisle by an arch covered by a gable, the crucifix stands directly in the gable (Foig. 822).

Yet this arrangement becomes impossible when the rood loft t terminates at top in a balcony or gallery.

In the last case are above the gallery between which extends the rood screen, and are connected by a wooden beam on which is placed the crucifix, or the latter is suspended by an iron rod directly from the keystone of the arch over it. In the cathedral at Lübeck is added to that receiving the crucifix the extremely rich wooden construction of the next spaces between piers.

The ornamental execution of tte rood loft varies according to the period of time.

For the simple mode of treatment peculiar to the older examples a specimen is given in Fig. 820, where the entire decoration consists of a relief filling the spandrels above the arch, that represent the rising from the dead, the ascension to heaven, the expulsion to hell, and in the extreme of our Fig. are no longer visible the mouth of hell with the damned.

On the later examples the execution of the architecture is even richer.

The arches are crowned by angular or recurved gables, usually having little suspended arches, between them rising canopies or enclosures of figures, whose tops sometimes rise above the upper gallery, the spandrels filled by tracery, the details ever finer, in brief the whole attains the overrich character, showing itself in its highest bloom on the little tabernacles for the sacrement.

With especial clearness is expressed this transformation on the rood loft of the cathedral at Lübeck, that in the 13 th centwry (Note) was executed in a very simple way in brickwork on four granite columns, and that corresponds about to the plan g given in Fig. 823. There the sole ornament indeed consisted in

painting those surfaces, that in Gelnhausen are covered by reliefs.

Note. According to the assumptions of Building Director Schwiening at Lübeck this dates from a later time.

But at the end of the 15 th century the entire outside to above the capitals was covered by an overrich but masterly executed paneling, whose arrangement is that indicated generally above, in the style peculiar to the last of Gothic, and which was originally painted in the greatest splendor of color.

8. Different Systems of Geometrical Proportion.

If the proper technical construction not alone leads to the various systems of the entirety and the forms developed from it, but even prescribes the dimensions for certain details, then as we have frequently indicated in the course of this work, there can occur also besides it a second purely geometrical method of construction, which is designed to accurately determine the different dimensions and to establish between them a certain harmonic proportion. (Note).

Note. That one must not value too highly the importance of a such proportions and dimensions has already been emphasized in the proper place.

There is no special peculiarity in such a procedure, no arbitrary discovery of the Gothic period of art, but according to recent investigations it is the transmitted inheritance of preceding centuries. More on hris is contained in the great work of Henczlman:-- "Theory of proportions applied in architecture."

However before and besides Henczlman were developed various other systems for the same purpose, that we must limit ourselves to generally indicating in the following.

The idea lying at the basis of all is to be sought in this, that the effect of every architectural form is obtained in the mass by decision and unity, when the different extremities of it can be circumscribed by a square or triangle of certain harmonic proportions, when further all subordinate divisions, groups and detail forms follow the same law, and accordingly the entire volumes of the whole stand in the like harmonic proportion to each other and to the whole. Before going farther, we must yet add that the following of this law can only be of value, where it is to be seen in perspective, therefore is only to be applied to points lying in the same horizontal or vertical plane.

The master's rules of Roriczer, etc., preserved to us en the Gothic A B C of Hoffstadt, as well as the system derived from mediaeval sketches and models consist in this, that first the details of the plan were found from the ground form of the same, thus from the square, equilateral triangle or pentagon, indeed by a simple division of the sides or diagonals, and further from the inscribing and circumscribing of the ground form, from setting it diagonally inside and outside, that also the different measures are to each other in the proportion of 1:2:3:4:5 etc., and with regard to the diagonals as 1:√2:2:√8 etc.; also with regard to the diagonals of cubes formed with the same ground form as 1 √3, etc. The relation of 2 √3 further results from t the relation of the side to the altitude in the equilateral triangle. In like manner the dimensions of the elevation are then also obtained from the proportions of the ground form, as generally the above conditions can be fully expressed in this way, when the choice of the magnitude concerned is the correct one. The latter has to be done by a freehand sketch, on whose value the completed work depends on the first place. An example of t procedure is presented by the later indicated Roriczer's construction of a finial.

Appearing substantially different, yet in reality leading to nearly the same results, is the system of Hay given in the English Builder in the year 1861. As shown in Fig. 824, its starting point is the right-angled triangle a b c with equal sides. The hypothenuse b c is then laid off from a to c on the ground line, e c is drawn and then c c is laid off from a to d, c d is drawn and laid off from a to d, c e drawn, etc., whose arcs with unimportant rectifications have the values 45°, 36°, 30° and 27°. Between these values are interpolated others produced from the rectangle, whose sides are to each other in the proportion of the side of the equilateral triangle to its altitude, thus a i c, then developed from the latter in the same way, no longer illustrated in our Fig., and further are added those found by doubling and halving those already obtained, so that the following scale results.

90°, 80°, 72°, 67 1/2°, 60°, 54°, 51 3/7°, 48°, 45°.
45°, 40°, 36°, 33 3/4°, 30°, 27°, 25 7/10°, 24°, 22 1/2°.
22 1/2°, 20°, 18°, 16 7/8°, 15°, 13 1/2°, 12 6/8°, 12°, 11 1/4°,

by which the different harmonic rectangles are determined, that

limit the various observed points in plan and elevation.

A similar though somewhat more complex system is that established by Henczelman. In Fig. 825 a b c is the triangle obtained from the proportions of the cube, $1 : \sqrt{2} : \sqrt{3}$. The smaller side b c is then the unit of the work to be constructed; in the Greek triangle it is the width of the cella, and probably that of the middle aisle in the Gothic church. From the triangle a b c by a method analogous to Hay's, by transferring the hypothenuses to the least side are found the triangles a d e, a f g, etc., and by transferring backward a c from the side of the hypothenuse, etca, are found the triangles a k l, a m n, a o p, etc., so that the sides of all triangles form a scale of sizes further formed by their division by two or four, that comprises the volumes and dimensions of the entire work as well as of all details.

In the Discourses on Architecture by Viollet-le-Duc on p. 393 et seq. is developed a system of construction, which like the worgs of this eminent author has the advantage of particular accuracy.

There are employed three different triangles; 1, the equilateral; 2, that made diagonally on the squared base of the normal pyramid formed according to the equilateral triangle; 3, that found in the following manner in Fig. 826. A b c is a right-angled triangle, whose sides as indicated by the dimensions given in the proportion as 3:4:5. At the middle of the base at 2 is erected a perpendicular, whose length = half the hypothenuse, i.e., = 2 1/2, and thereby is found the triangle a e b, namely the normal section of the pyramid of Cheops.

The height of this triangle compared to that taken as the unit of the ground line would be first, $\sqrt{3/4}$ = 0.86603; second, $\sqrt{3/8}$ = 0.61237; third, 5/8 = 0.625. (Between the last two is the golden mean = 0.618). In his Dictionary (Vol. VII, p. 535) the same author gives three triangles, two of which agree with those previously explained. These three are:- 1, the right-angled one with two equal sides, whose altitude = half the base; 2, the so-called Egyptian triangle with two equal sides and an altitude = 5/8 of its base (see above); 3, the equilateral triangle.

To follow the systems mentioned and others in their details may be omitted, since wot all are based with sufficient conclusiveness to entirely exclude objections, that the fame of their authors may have contributed something here to them.

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Emeritus Professor of Architecture

UNIVERSITY OF ILLINOIS

Urbana. Ill.

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V. THE CHURCH IN CROSS SECTION AND ELEVATION.

1..Single-aisled church and single-aisled choir..

Proportions of the height of the interior.

In the development of the cross-section of the church from the general form of plan are first to be considered the requirements of the vaulting, those of the introduction of light and the endeavor for a perfected architectural expression in the interior and on the exterior. For a church with a single aisle it is possible for all to become suitable at the same time without special difficulty.

To the vaults may always be opposed external abutments sufficiently strong, even with very great thrusts, it is only for r reasons of economy, which also in single-aisled churches indicate the limiting of the mass of the vaults and abutments. Light may be intriduced through side wallu in sufficient abundance, and no great restraints are laid on the artistic form; it can move quite freely in the development of the details and elso in fixing the main proportions.

The proportion of the height of the whole and of the diffeeent parts quite strongly influences the character of the architectural structure. Consideration of mediaeval works also allows here the recognition of an infinite diversity. Indeed is expressed in the buildings of different countries in the dimensions of the heights a certain relationship, but this is subject to a change in its divisions of time, and in special cases is broken through by the endeavor for the development of greater magnificence and higher elevation.

On the average the height experienced an increase in the course of centuries, which abouh held an equal pace with the enlargement of the window surfaces and the restriction of the masses of the walls. Yet at all times beside those proud and lofty works also appear those of quite modest height, since the building materials at command here exerted important influences.

Heights of the springing of the vault and the crown.

The first requirement is indeed that the height of the springing of the vault (h in Fig. 827) and also the height of the c crown (H) is in an intelligible ratio to the width, in other words that the form of the cross section cut through the cross vault is pleasing to the eye.

Certainly the effect of this cross section also depends on a certain dependence on the length of the entire interior as well as that of a single bay, the elevation of the vault, the arrangement of the windows; it can notable affect the happy proportions by the influences of this kind.

This length of the entire church is so far influential, since for small lengths the height should also not be too important, and so as to make the general view of the vault still intelligible to the eye, the height should never be more than half the length. Concerning a choir adjoining the church, the length of the nave naturally comes in consideration.

If one desires to make a difference between churches with small, medium and great height of the nave, the limits can be drawn as follows:-

A church is to be termed low, when the springing od its vaults is raised above the floor less than the width of the nave (h ÷ b lessthan 1), or which amounts to about the same, whose total height to the crown remains less than 1 1/2 times the width of the nave. Here belong many chapels and numerous little village churches, but also many large single-aisled churches, that on account of great span of their vaults rise to an important height. In many village churches the springing of the vault lies at about the height of the head or even lower, while the crown of the vault scarcely attains a height equal to that of the clear width of the span. As an example among many may serve the little church of the village of Volksen near Einbect belonging to middle Gothic, which with a span of about 6 m shows a height of the springing of 1.8 m and a height of crown of not 5 m. With this small height it has only two short bays and a triangular choir ending, so that its effect is not at all too depressed.

A mean height results if the springing of the vault is 1 to 1 1/2 times the width of the nave, or the crown of the vault is 1 1/2 to 2 1/2 times the width. Very many small and large churches of the Romanesque and Gothic periods, whose interiors make a particularly interesting impression, remain within these limits, and also the quite slender effect of the upper story of S. Chapelle at Paris does not exceed these proportions in height.

As slender must be termed a single-aisled churcth if the proportion of height exceeds the limits just indicated, but the

height of the springing of the vault seldom rises above twice the span of the vault, and the height of the keystone oves 2 1/4 times the width of the nave. The middle aisle of churches with several aisles, which has a certain relation to the total width,and which besides must often be extended high on account of the introduction of light, averages higher than the nave of the simple church, often exceeding three times the width (Cologne).

Geometrical relation between height and width.

If one seeks satisfactory geometric relations between height and width, especially between the height of the springing of the vault (h in Fig. 827), and the clear width b (the latter being understood as in the clear between the projections, or measured between the planes of the side arches or the face of the wall), then can the following exist.

1. Height = half width (h = 0.5b).

2. Height = half diagonal of square of width (h = 0.707 b). This ratio appears among others to occur in the church of S.Maria Selspritsch in Carinthia, and in the choir of the church at Wolksmarsen belonging to the early Westphalian group.

3. Height = width (h = b). Choir of Early Gothic church, Late Gothic S. Martin's church at Cassel and the longitudinal aisle of many other churches.

4. Height = diagonal of square of width (h = 1.4142 b). Choir of S. Elisabeth at Marburg, S. Severi at Erfurt, church at Immenhausen in Hesse, nave of S. Chapelle in Paris, etc.

5. Height = 1 1/2 times width (h = 1.5 b). Choir of church at Friedberg.

6. Height = twice the span (h = 2 b). S. Maria at Mühlhausen.

The information preserved by F. Lacher (Reichensperger, Mixed Writings) goes from the total height to the crown of the vault, and requires for this 1 1/2 times the width (which he terms the right height), or even 2 or 3 widths. Lacher further fixes the rise of the vault, when he makes the diagonal arches semicircles and gives equal heights to the cross and side arches. In the 1 last precept the treatise mentioned calls such a vault a correct vault.

The roof of the single aisled church.

The outer wall above the vaults has no further problem to satis fy than to bear the beams and framework of the roof. Accord-

Accordingly on most Romanesque and Gothic buildings it is only carried so high that the roof beams extending over the vaults rest on it, and even in bending by accident loads do not touch the outer surfaces of the compartments. For this purpose usually suffices a space of 10 to 30 cm.

Passing over the attic floor.

Beneath each pair of rafters may lie a beam, so that the average distance between them is only about 1 m. In this case it is easy to make the attic floor passable by logs laid on them or also by a closed flooring. But convenient travel over the floor is usually so little required, that men are unwilling to employ a complete series of beams. Therefore in ancient and modern times they often use through beams only where required to resist the thrust of the roof, and then have distances of 2.5 to 5 m or even more. If in such a case it is desired to make the attic floor passable for use, they may larger logs or even small beams be laid across it, but heavy loads are then to be avoided.

Frequently the beams are not utilized at all, but the vaults are directly used for passing through the attic, and then the beams can be placed so high that one can go beneath them or are arranged at greater distances just above the vaults, so that t they do not hender passage

A higher location of the beams is made possible in three ways.

Raising the beams.

1. The external walls are carried so high, that one can pass under the beams lying on them. The partial walls produced thereby can give a desirable overload for the side aisles and also favor the development of a dignified main cornice on the exterior. Such an elevation above the height of the head is however seldom found (Rheims), but it is somewhat more common that men are satisfied to raise the beams 1 to 1 1/2 m above the vaults, so that in p passing over these it is necessary to bend at every beam.

2. To save masonry the walls are not continued up in their entire thickness, but only as a thin wall lying behind the gutter parapet (Fig. 829).

3. The beams are placed higher in the construction of the roof. (Fig. 830). The wall then ends directly over the side aisles, the rafters standing on little ties laid on the wall plates. For the length of the rafters not to bend under the collar beams an-

anchoring them, there are added the struts d and braces c. Such a construction is found in S. Blasien in Mühlhausen. Yet more firmly is held the foot of the rafter py the framework indicated in Fig. 831, where the beam is better replaced by ties.

Roof framework with a smaller height of wall.

A higher position of the beam, solely on account of the passage over the vaults, however belongs to the exceptions, since it must be purchased by a greater quantity of masonry or a less reliable combination of the roofs, it occurs far more frequently that the outer wall is made as low as possible to save masonry. Particularly very strongly raised vaults frequently rise into the attic, while the tiebeams only pass through above the 1 lower cross arches,or even roof framework in the mode of Figs. 830 and 831 is employed, which then has a greater justification.

Isolated trussed beams.

When merely isolated beams pass through, the intermediate short blocks are prevented from displacement by the rafters. To lay them on the wall merely fastened to it is not proper, since a transfer of the thrust of the roof to the wall is quite undesirable (as shown on p. 163 et seq., the wind pressure striking on the opposed half of the roof is sufficient to create a portion transferred through the roof). Therefore the thrust of the blocks would be led to the through beams, which can be done by special cross beams or even by the wall plate. If the cross beams are long (a in Fig. 832), they are prevented from bending by small braces b or by horizontal little diagonals c. A lack of braces in construction always causes that the rafters must always connected by fastenings to resist tension. Therefore in the middle ages the wall plates were more generally utilized to transfer the thrust, when deeply gained into them. For small distances between the main beams there sufficed two broad wall plates without other aids, but for greater distances between b beams two struts were placed between the wall plates (Fig. 833), or as represented in Fig. 833 a representing the roof framework of the church of S. Nicolai at Reval.

Some statements concerning beams and roof framework will be given later in the description of hall churches. An exhaustive representation of the extremely varied mediaeval roof combinations must remain for separate treatment, but here it man at least

be indicated that in the middle ages the extreme waste of timber of later centuries was unknown, that men avoided ends of timbers with insecure fastenings, especially for parts in tension, and preferred indents or splices of moderate depth, even when certain tiebeams must extend obliquely.

The covering of the roof extends over so far, that the water drops directly from it (Fig. 834) or by a wash is carried to a drip of the main cornice, in case no gutter is provided. (Further see p. 362 and later under Cornices).

Reduction of thickness of wall upward.

Reasons for small reductions.

The external wall of a single-aisled church or choir, likewise the wall of the hall church or of the side aisle of the basilica, rises not entirely or with nearly equalthickness from the ground to the main cornice. The Romanesque churches only show a slight p projection at the base, while the Gothic also mostly exhibits a slight offset at the height of the window sill moulding.

It may appear surprising, that the external increase of thickness downward was not carried farther in order to approxemate as nearly as possible to the ideal form of resistance (Fig. 343). But this would certainly have occurred if men had to do with resisting a uniform thrust of a vault; but now occurred besides that also varying stresses, especially under the influence of the wind. The wind pressure in the wall struck by it is opposed to the thrust of the vault, it may in many cases even be greater than the latter and therefore strive to incline the wall inward. The opposite wall will also receive a part of the wind pressure through the framework of the roof and in some cases through the crown of the vault (see below). But the higher that a side force is applied, so much the less is it possible to reduce the thickness of the wall upward. In the limiting case with only a great horizontal that strikes the top of the wall rising with the same thickness and without overload, the danger of overturning would be equally great above each bed joint from the bottom to the top. Even for the upper courses would occur the possibility of sliding, that would vanish for the lower part of the wall (in which again the compression is greater under the influence of the masonry loading it). This limit indeed does not exist for the wall of a church, since a certain overload exists and the great thrust

of the cross vault acts far below in the springing of the vault, moreover from the preceding it would appear that the diminishing of the wall could not be carried too far on account of the effect of the wind. Particularly then if the buttresses are already strongly diminished, so much the more occasion is there to leave the wall full above, and indeed this can even be required to m make the wall thicker above wide windows, as will be proved somewhat later.

The resistance of the walls,to the thrust of the vaults is treated on p. 137 to 152, and as opposed to the wind pressure on p. 163 to 165. Since no examples of calculations are given there, let two of them be interpolated here as illustrative.

Example 1. Investigation of the stability of a single aisled church without buttresses, with and without the effect of the wind. Fig. 835. The church has 10 m clear width with 6 m length of bays, and 20 m height of wall above the plinth and internal floor. It is vaulted with cross vaults of porous bricks 1 brick thick with a rise of 2/3 measured crosswise, and the abacus lies 13 m above the floor. Each wall space is opened by a window 2.8 m wide and averaging 13 m high above the sill course 4 m from the floor, the part of the wall under the window has blind arches and must be regarded as not adding strength of it. Otherwise the wall of sandstone weighs 2200 kil per cu. m., with a thickness of 1.5 m below the sill course and of 1.4 m above it.

Forces H and V of the vaults. On a wall space rests half a vault withan area of 6 × 5 = 30 sq. m. According to p. 135 IV c each sq. m. area on plan exerts a horizontal thrust H_0 = 180 kil and a load on abutment of V_0 = 530 kil; thus for the vault, H = 30 × 180 = 5400 kil, and V = 30 × 530 = 15900 kil. The intersection of the vault thrust with the face of the wall can be assumet at 1.6 m above the capital or 14.6 m above the floor.

Weight of the wall. The volume of the lower part of the wall weighs Q_1 = (6.0 - 2.8) × 1.5 × 4.0 × 2200 = 42240 kil. The upper part of the wall above the sill course weighs Q_2 = (6.0 × 16.0 - 2.8 × 13.0) × 1.4 × 2200 = 18356 kil Together $Q_1 + Q_2$ = 225808 k.

Weight of roof. For 90 kil per sq. m. of roof surface with f framework and slate covering (p. 162) each half of the roof weighs 6.0 × 9.4 × 90 = 5076 kil = D. As vertical component of wind load for about 50° inclination according to Table on pa 163; on the windward side = 6.0 × 9.4 × 23 = 1297 kil; on leeward side =

6.0 × 9.4 × 35 = 1974 kil. Adding these to the weight of the r roof gives for the windward side 6373 kil = D; on the leeward side D″ = 7050 kil.

The horizontal wind thrust of the roof according to Table on p. 163 amouts to 6.0 × 9.4 × 69 = 3892 kil. The distribution of this thrust on the two walls can be determined, it may be assumed that the windward side receives S′ = 1892 kil and on the leeward side S″ = 2000 kil.

Wind pressure against the wall. With regard to protecting adjacent buildings, let the wind be neglected on the lower 4 m in height, but on the upper part of the wall 14 m high is taken the full pressure of 120 kil per sq. m. Then the wind pressure amounts to 6.0 × 16.0 × 120 = 11520 kil with its centre of application at 12 m high.

In this case the wall will be most strongly stresses in the bed joint above the plinth, and it therefore will be limited to the investigation at the cross section.

A. Compression above the plinth without wind. For an unknown point of intersection by the resultant compression, which lies at X m from the internal face of the wall, there is established the equation of moments of all forces acting on the wall panel. (See on this Fig. 371 on p. 140).

$Q_1 (X - 0.75) + Q_2(X - 0.70) + V X = H \times 14.6.$

If for Q_1, Q_2, V and H are substituted their numerical values above, then is computed X = 0.99 m.

Thus the compression occurs at 0.99 m from the internal face and 0.51 m from the external surface in the horizontal area of the wall 1.50 m thick, so that it lies at the edge of the middle third.(Kern).

The horizontal area of the part of the wall considered between the windows amounts to 1.50 × 3.20 = 4.80 sq. m = 48000 sq cm. On this area rests the load = $Q_1 + Q_2 + V$ = 242000 kil in round numbers, or = 247000 kil if the roof load is added. The average compression accordingly = $\frac{247000}{48000}$ = 5.2 kil per sq. cm. The compression at the outer edge is twice as much, thus about 10 kil. The compression diminishes upward in the wall, but will be distributed below over a larger area by the rapid widening of the plinth of the lower wall.

B. Wind pressure on the wall struck by the wind. To the preceding are added the forces D′, S′ and W; the equation of moments

is established in the same manner for the unknown pivot, which is X′ m. from the internal surface of the internal surface of the wall.

$Q_1(X' - 0.75) + Q_2(X' - 0.70) + VX' + D'(X'-0.70) = H \times 14.6 - W \times 12.0 - S' \times 20.0$. Substituting the given numerical values, there results:- $X' = 0.27$ m.

While usually the compression lies nearest the outer face, under the effect of the wind it recedes to near the inner face (nearly to 1/6 the thickness) and produces there a compression that nearly equals four times the average compression (p. 144 and Table on p. 145), thus amounting to about 20 kil per sq cm.

C. Compression in the leeward wall. There act the forces Q_1, Q_2, V, H, D″ and S″, for which the equation of moments for the pivot X″ m from inside of wall is:- $Q_1(X'' - 0.75) + Q_2(X''-0.70) + V X'' + D''(X''-0.70) = H \times 14.6 + S'' \times 20$. $X'' = 1.14$ m.

The compression recedes to 0.36 m from the outer edge, and there produces a compression at the edge of about 15 kil sq cm.

Stability of a wall with buttresses.

Example II. Investigation of the same wall assuming a thinner wall with larger windows and with buttresses.

The wall is 1 m thick and is opened by great windows, that with the wall beneath them have an average height of 17 m and a width of 4.5 m. The buttresses are 18 m high and 1 m thick, projecting 1.5 m below and 0.70 m above, thus 1.10 m as an average from the wall, their centre of gravity lying 0.57 m outside the external face of the wall and 1.57 m from the inner face.

Weight of wall = $Q = (6.0 \times 20 - 4.5 \times 17.0) \times 1.0 \times 2200 =$ 95700 kil (= 43.5 cu. m).

Weight of projecting buttress = $P = 18.0 \times 1.0 \times 1.1 \times 2200$ = 43500 kil (= 19.8 cu. m.

A. Compression above plinth without wind pressure. There is again sought the equation of moments for the pivot at the centre of compression lying at the unknown distance X from the inner face of the wall.

$$Q(X - 0.5) + P(X - 1.57) + V X = H \times 14.6. \quad X = 1.26 \text{ m.}$$

For the horizontal area of the buttress and the supporting part of the wall = 3.0 sq. m or 30000 sq. cm, the average compression is computed at 5.4 or 5.2 kil per sq. cm, according as the roof load is added or not. For the already calculated location of the compression, that remains inside the kern, the com-

compression at the outside edge is about 8 or 9 kil per sq cm.

B. Compression in the windward wall. Corresponding to the preceding:-

$Q(X' - 0.5) + P(X' - 1.57) + V X' + D'(X' - 0.5) = H \times 14.6 - W \times 12.0 - S \times 20.0.$ $X' = 0.14$ m.

C. Compression in leeward wall.

$Q(X'' - 0.5) + P(X'' - 1.57) + V X'' + D''(X'' - 0.5) = H \times 14.6 - S'' \times 20.0.$ $X'' = 1.47$ m.

At the leeward wall the line of support is thus more than 1 m from the outer edge, so that the latter receives a compression not much over 10 kil per sq. cm. On the contrary at the windward side the pressure at the edge would rise to about 50 kil per sq. cm. (Then according to p. 144 only the area of 3 × 14 = 42 cm wide, thus for 1.5 cm length with an area of 0.64 sq. m takes part in the transmission of the compression. Since the load amounts to about 162000 kil, there comes 22.5 kil per sq. cm as the average, and the compression at the edge would be twice as great, thus being = 51 kil). If the wall alone existed, there would occur with good construction a not exactly dangerous stress, but one always much exceeding the allowable amount (20 to 25 kil per sq. cm for good sandstone in cement). But now is found an adjustment between the stresses in both walls, for neither wall is so rigid, that it does not bend somewhat before the wind, and the windward and more strongly stressed wall yields more than the other and consequently leans more at top against the vaults, and by this and also the roof beams transfer a part of its side forces to the other wall, until both are nearly stressed equally. Thereby in both walls the compression attains about the same magnitude. If in this manner about 1/4 or 1/5 of the wind pressure is transferred to the other side, so that the centre of pressure below moves about 20 cm, it is then at the windward side about 34 cm and at the leeward side about 167 cm from the internal surface, whereby the edge compression is reduced to about 20 kil per sq. cm and results somewhat smaller at the opposite side.

It also shows that in thick walls of not only a basilica, but also already in any similar church must be possible a reciprocal bracing of the upper part of the wall, whether this be by the crown of a vault, the cross arches or the roof beams. Moreover such effects of wind occur very rarely and often not in decades.

The more common winds of moderate pressure make unnecessary an upper transfer, as they will mostly even rather lessen the edge pressure than increase it in the windward wall. Seldom will the pressures in the preceding example much exceed 10 to 12 kil per sq. cm.

Comparison of volume of the wall with and without buttresses.

In both examples the stress in the masonry seems about equally great for erection with or without buttresses, but the solid w wall requires about 1 1/2 times the volume. By a still greater reduction in thickness of the wall and increased size of window with a contemporary shortening of the pier even more volume can be saved, there are limits drawn here. So far as the wall lies under the side arches may it be resolved entirely into the window and the blank wall beneath, assigning its task to the pier, but the side arch above alwans retains its great statical importance, that is here the more important, the more the masonry is otherwise restricted.

The side arch and the masonry above it.

Task of the side arch aod the masonry on it.

Besides the buttress, the side arch and the masonry over it is the most important part of the supporting masonry. The tasks of the side arch and of the upper masonry are so varied, that they require close consideration. They have to:-

1. Connect the adjacent buttresses in the wall plane.
2. Receive the thrusts acting in the parts of the upper vaults (particularly for raised vaults).
3. Bear the roof load.
4. Transfer the wind thrust against the roof and the upper p part of the wall to the buttresses.

Bracing in the plane of the wall.

Bracing in the wall plane is the more necessary, the more are to be expected forces acting longitudinally from various great thrusts, effects of wind, various settlements, etc., and the m more the remaining width of the wall is reduced by a wide window, the higher is the wall and the narrower are the buttresses.

The wall above the side arch forms an immovable shape restricted by the inclination of the buttresses, and certainly it is required that over the crown of the window shall remain a sufficiently strong portion of the wall to resist displacement in the manner of Fig. 836. If the window must rise very high, then

a gable can strengthen this part.

Below the window sill course the portion of the wall connecting the buttresses again forms a strong longitudinal stiffening. If this part is resolved into blind windows, at least a strong connection over at and under the window is advisable, that of itself results from the arrangement of a passage of this height.

There remains only the possibility of a bending of the buttresses at the height of the window as in Figs. 837 and 837 a. W With a smaller height of the window neither is to be feared, and with a very considerable height a later horizontal division of the window is made by a passage, as found in S. Elisabeth's church at Marburg. It is particularly in place in single-aisled choir and transepts of tall basilicas, in which a division in height is otherwise given by the adjacent parts with several aisles. Very high windows are accessible with difficulty and a are easily unsatisfactory in effect, and thus the long windows like stilts in the transverse aisle of some churches in Mecklenburg are almost disturbing.

Reception of the thrust of the vault.

2. The thrust of a vault is borne by the side arches for swelled and raised vaults, and it is shown on p. 50 et seq. how its probable magnitude is obtained. But an ordinary cross vault with straight ridge can also exert a thrust on the upper part of the side arch, when by the mode of construction, crushing or other accidents, the stresses are guided in this direction (p. 47). Now certainly in such a cross vault the side arches avoid these stresses by a very slight yielding, and then all parts of the vault without necessarily endangering its strength must seek its support in the regular way from the ribs and springings. Such a transposition of the pressure usually does not occur without small cracks or crushing, and it is therefore well for the side arches to be sufficiently stiff to resist in a certain degree such accidental effects. Greater external forces (wind and the like) that may be transferred to the side arches by the vaults will very soon be treated particularly.

Reception of the roof load.

The distribution of the roof load depends on the kind of roof framework. If a purlin roof is employed, whose main trusses rest on the buttresses, then the intermediate trusses will load the side arches but little, but if all trusses are alike, then the

weight is continuously distributed over the entire length of w wall. The vertical loads of the roof, that are usually small in comparison to the weight of the masonry, rarely injure the side arches, and therefore are rather desirable than heavy. It is otherwise with the sidewise forces that the roof framework may transfer to the wall. Aside from the wind (see below), they may be produced by a defective resistance of the thrust, in case of collar beams placed higher (Figs. 830, 831), or braced (Figs. 832, 833). Strong thrusts from the roof should ever be prevented in a structure by a proper choice of the roof connections, since alreadn the unavoidable sidewise movements by the wind at this height suffice to create.

Reception of the wind thrust.

4. The wind thrust against the roof and walls can for the wall over the side arch be more important than all preceding influences. The wind pressure against the roof is to be resolved into a vertical wind load and a horizontal wind thrust (Table on p. 163). The first is added to the roof load and like that is more useful than injurious. The horizontal wind thrust whose magnitude is given in the last column of the Table on p. 163, must be received by one or the other wall or by both; how it is divided between the two sides is not generally to be said.

If the roof framework occurs with a strong beam under each t truss (Fig. 838), the roof in itself forms an unchangeable figure, which the wind seeks to thrust sidewise in its entire form. The friction of the beam or plates on the level top of the wall hinders a sliding of the roof (anchors are usually unnecessary for the friction is generally sufficient with a free bedding). But if the roof cannot slide on the masonry, it would seek to press this over, so that the entire wind thrust finally acts on the walls.

If both walls are equally resistant, then will about equally take part in the thrust, perhaps the wall receiving the greater vertical load will also have more thrust. On the contrary if one wall be less stable in consequence of its form or of other forces already thrusting it sidewise, the weaker wall will already yield somewhat after it has received a small part of the thrust, and then the greater portion must be transferred through the beams to the other resistant wall (Fig. 838 a) where the weak wall is represented as a hinged support, clearly illustrating

this). A strong series of roof beams can even transfer a part of this wind pressure against the wall to the other side, but then is to be an anchoring of the beams to the wall and a good securing of the upper part of the wall against overturning, sliding and bulging is to be kept in mind. The thin parts of walls usual in parapets (Fig. 829) are then unsuitable.

If instead of the full series of beams only braces or collar beams exist (Fig. 830), then the roof framework is less able to transfer the wind thrust to the stronger wall, and the weaker wall must chiefly take its part on itself, and it can only relieve itself by the interposition of a stiff vault below it.

For purlin or trussed roofs the wind pressure comes to act in the trusses, and these are placed above the buttresses carried sufficiently high, so that the movements of the wind can be kept away from the intermediate wallu. But if division in bays requires an intermediate main truss above the crown of the side arch, this is the more exposed to the movements.

When the wall exposed to the wind is not sufficiently stable to receive the thrust of the wind (see p. 167 to 169 concerning the basilica of Example II, p. 337, in regard to single-aisled churches), a part of it must be transferred to the other wall, which is made possible by a stiff cross arch (Fig. 413) or the ridge of the vault (Fig. 412). If the vault cannot make a greater transmission of pressure (for example a light tunnel net vault without cross arches), then in case of need as just stated, the roof beams must lend themselves to stiffen it.

Among these effects of forces against the clearstory wall are naturally most important the sidewise forces produced by the vaults or the wind, for slender basilicas with thin piers the thrusts may gather in their upper walls, that equal or even exceed the regular thrusts existing in the springing od the vault. In single-aisled hall churches or those with several aisles, t they must never be underestimated. Example II, p. 337, gave to the leeward side a wind thrust of about 5000 kil transmitted by the roof and the ridge of the vault, which thus is even not much below the vault thrust of 5400 kil acting lower down.

Under these forces may the upper courses of the wall be either moved, or the masonry above the buttresses may be inclined, or finally the wall may bulge between the buttresses.

Sliding of the upper courses.

A slipping of the upper courses may most easily occur if the building is already struck by a great storm before the mortar is hardened, and before the stiffening vaults are turned. The exposed wall, so far as it cannot itself master it, seeks to g guide it to the other side by means of the framework of the roof, whereby the roof beams or together with the upper courses of masonry may be slipped. Where it seems to be required, this danger can be prevented by a preparatory stiffening of the wall and by anchoring the framework of the roof and also the upper courses of masonry together (stone or metal dowerl).-If the mortar is hardened, a sliding of the courses is no longer to be feared, so long as over each joint the vertical load is 1 1/2 to 2 times as great as the horizontal force.

To the wind thrust against the roof should usually correspond a sufficiently great roof load, as in the example on p. 336 a thrust of 3892 kil, that could act on a roof in the most unfavorable cases, while the roof load for this wall would amount to 7050 kil. But if a greater wind thrust against the wall is to be transferred through the ridge of the vault, then maw the vertical load be shown as too small. It is then to be increased by making the wall thicker or higher in its entire length above the vault, or by adding gables at the dangerous points, when instead of stiffening, i.ea, transferring the wind pressure through the ridge of the vault, this is not possible through the cross arch to a point somewhat lower.

Overthrow of the upper part of the wall.

The overturning of the upper part of the wall may occur, when for thin walls the buttresses (or flying buttresses on basilicas) are not extended sufficiently high, or if the depths of the buttresses is diminished too much upward. The stability can easily be investigated, when for the bed joints above the buttresses or over their offsets, the curve of pressure is sought in the usual manner (see p. 140).

Bending of the upper wall outward.

A bending of the wall between the buttresses is to be feared, when the buttresses are sufficiently high and strong, but the wall is too thin. With stiff cross arches will the wall exposed to the wind be most affected by bending, (Fig. 413), but with stiff ridges of the vault it will be more the leeward wall (Fig. 412). For the exposed wall it is less to be feared, since it

leans against the vault compartments and can support itself through these against the opposite wall or in an oblique direction against the stiff cross arch. On the contrary for the leeward wall bulging outward is vern easily possible, since there the wind thrust is added to the perhaps already existing thrust acting in the ridge of the vault.

The behavior of the wall under the forces bending it outward may be explained by Figs. 839 and 839 a. One cannot count on a resistance to bending in the horizontal plane of the wall, as occurs in a beam in question, since the masonry can be assigned no tensile stresses, and the wall can only offer resistance in this case by its horizontal ability to support, i.e., by the possibility of developing a line of support in its ground plan. This line of support is best assumed, so that it passes within the middle third (thus $c = \frac{d}{3}$). The lines of support of two adjacent bays join at the point P and there produce a force to be received by the buttress, which equals the sum of all thrusts acting on the length of the bay. If one also desires to know how great is the force D acting in the curve of support, then is established for half a bay the equation of moments for the point P, which is D c = R a, in which R is the resultant if all thrusts acting in half the vault. The greatest edge pressure at the point B is found when $d = \frac{2D}{F}$, where F = the cross section in sq. cm of the resisting masonry here above the crown of the side

The line of support drawn in the plan in Fig. 839 a must not be conceived to lie in a horizontal plane; while it gradually moves outward from G to P, it at the same time moves downward as shown in the elevation (Fig. 839). The greater the weight of the wall in comparison to the thrust, so much the more rapidly does the line pass downward. One can assume about $\frac{e}{c} = \frac{Q}{S}$, when Q = weight of a side arch load and S = sum of the thrusts coming above on a bay. From this simple relation may be approximately calculated the height of the point P, thereby determining how high must be extended the buttresses. In Example II, p 337, the weight Q is computed at about 48000 kil, and the thrust S in the most unfavorable case at 5000, c at 0.33 m (= 1/3 thickness of wall), and thereby e results = $\frac{0.33 \times 48000}{5000}$ = 3.2 m. The point P to which at least the buttress is to be carried would thus be about 3 to 3 1/2 m below the eaves.

The greater the side forces acting on the upper part of the

wall, and the smaller the weight of the wall above the side arches, the higher must the buttress extend. For basilicas the point of application P_2 may attain such a high location (it is to be found in the way just given), that the ending of the flying buttresses close beneath the eaves may be imperatively neeessa

That the wall with the forces acting on it both horizontally and vertically may safely bear on the buttresses, a good joining of the stones by indenting or if necessary, also by mechanical aids is important. That men did not overlook this requirement also in earlier times is shown among other things by the relieving arches, which have often been added over the apexes of the windows of the wall, as at Amiens, Troyes and the S. Chapelle in Paris.

Treatment of the upper part of the wall.

If it is demonstrated above in what way are to be provided t the requirements in the upper part of the wall, it is now asked how these are to be justified. There is an entire series of different solutions to follow, indeed occurring in many old examples, whose prencipal members may be stated here.

1. The wall has small windows and no buttresses, it is so thick from bottom to top, that it safely resists the horizontal forces acting everywhere at different heights.

2. The wall has windows of moderate size and moderately wide buttresses. The buttresses have only to resist the thrust of the vaults at the height of the springing. All other forces the wall itself can resist, it being sufficiently thick from b bottom to top to be sufficiently safe from overturning.

3. The windows open from buttress to buttress, to which all side forces must be led. Side and window arches are combined, the wall is made thicker over the side arches for better stiffening rekuired in the case, either externally by the projection of the arch mouldings from the sides of the buttresses, or inside by corbelling out over the vaults.

4. The side arch is moved inward, between it and the window wall is inserted a tunnel arch, otherwise being as before. This treatment most naturally occurs by projecting the pier inside.

5. The upper load is increased by gables. The gables by their weight prevent from sliding or inclination of the upper courses of the wall, they bring the line of support (Fig. 839) in accordance with the pointed form of the side arch, strengthen its

crown by high windows, Fig. 836. The heavier theload of the gable, the thinner may either be the wall over the windows, or t the lower may the buttresses stop.

6. So far as possible, all forces would be directly led to t the buttress, that is carried very high, on the other hand is kept as far as possible from the wall bay. This will be attained by suitable construction of the roof (for example a purlin roof with main trusses over the buttresses), by a corresponding form of vault (not thrusting at the ridge), and particularly by the use of a stiffened cross arch (Fig. 413), that forms a closed transverse connection from a buttress to lying opposite.

By the last method is the mass of the wall most effectively reduced, even so far that the side arches as in the churches of Burgundy from the Early gothic (Fig. 348) make themselves entirely independend of the external wall. But entirely aside from this astonishing boldness, it is always advantageous to a church both in regard to the economy of masses made possible thereby, as very particularly on account of the less mobility of the parts concerned, to transfer all side forces if possible to the cross arches and buttresses.

On the whole the six modes of execution mentioned represent a graduated series from harder to easier construction, and further intermediate steps may be inserted, since certain ones may be joined together with good results.

On the architectural treatment of the upper part of the wall, see later under Gables, Cornices etc.

The lower part of the wall.

The form and treatment of the cornice is treated farther below in a special section, for the general cross section of the church only its height and projection comes into consideration come into consideration. Usually the external wall has three cornices, the simply profiled projection of the plinth in one or two divisions at the height of the internal floor or the internal cornice continuing beneath the window parapet, usually a cap moulding crowning the offset of the wall, and the main or eave cornice occupying the first place on account of its architectural and practical importance.

Wide projections of cornices, so far as practically valuable can be simply constructed with the materials at hand, are allowed by mediaeval art within proper limits, but usually it does

not give to the cornice that unlimited predominance like antique art or the Renaissance. In any case they avoided aiding storms by too great projections, or to even afford opportunities to the architect for the execution in the before mentioned materials.

To give general rules on the distance of the projection is not possible, since also here practical and artistic considerations may occur in manifold relations. The late time certainly has also sought to arrange these members in a general scheme.

In Lacher the difference between the half thickness of the wall and the half diagonel of the same is given as the measure of the projection of all cornices, so that thus a b c in Fig. 841 gives the profile of the cap extending around below the windows (sill moulding) and a e b c is that of the roof cornice. The s same mode of determining dimensions is also found in Hoffstadt. But Lacher also introduces elsewhere another measure of projection, namely half the depth of the window jamb, which he again fixes at 1/3 the thickness of the wall, thus being f g in Fig. 841. He then also gives the same distance to the projection of the plinth, but it is to be noted in this that these dimensions assume the theckness of the wall to be 1/10 the clear width of the choir. According to this rule the cornice would project about 1/5 or 1/6 of the thickness of the wall. These projections are frequently confirmed on the works of the 14 th and 15 th centuries. But on the Early Gothic works the roof cornice as a rule has a greater projection, and especially if it forms a gutter for water.

Generally it is first the structural function of the cornice that determines its projection en every single case, and the thickness of the wall that sets a maximum for it by the possibility of execution.

But further we might for the simple cornices only fulfilling the function of carrying off the drip, as assumed in Fig. 840, also make the projection dependent on the distance between two cornices over each other, so that the roof cornice, whose distance from the window sill cap is greater than from that to the ground, and thus has to protect a greater height of the wall must also have a greater projection. In reality this wider projection on the later works is found in the projecting edge of the roof, but on the older was already made by the form of the cornice. Therefore we might sooner give the preference to the

to the arrangement of a more projecting roof cornice, than of its lesser projection on the later works that must be referred to a certain timid ty for a definitely expressed horizontal termination, which characterized the later style, but is entirely foreign to that of the 13 th century. It is further possible that the peculiar crowning of the window gable rising above the roof cornice on the richer works from the 14 th centuryonward allowed the horizontal termination to appear as a possible denial of a characteristic of poverty.

Therefore if the before mentioned determinations of the measure of the projection at first also seem suited for the window sill cap, then is found the equality of this projection with that of the plinth is just as little retained accurately on the older works, as it is founded in the nature of the thing. Accordingly these rules at most have only the use of affording certain starting points for avoiding exaggerations and disproportions, and another will also not claim the very words of master Lacher, for he says himself, "but it is not thereby stated, that you must follow him in all things, than what seems better to you, that it may be better according to your good idea; it is useful to everyone when he can, and knows how to employ something."

Plinth.

The base in the beginning with a preference for the Attic base was correspondingly divided, or was even composed of rounds and hollows, that on account of a good removal of water was simplified or condensed. Also already early appeared occasionally on the exterior a simple wash, that gradually became more common and finally lent to the cap of the plinth even the name of wash moulding.

The height of the plinth from the ground outside is found to be determined by the measure of the thickness of the wall in n nearly all preserved rules of the masters, and then by Lacher this determination is extended, so that the plinth should follow the irregularities of the ground by steps. Such an arrangement is foreign to modern architecture in a special degree. Therefore we show in Fig. 842 the arrangement of the plinth of the church at Frankenberg. A greater height of the wash moulding is then found, especially where it is divided in two or more parts.

The plinth occurs either alone on the exterior or also in the interior as assumed in the right half of Fig. 840. But since as

a rule the internal height from the floor is higher than the external, so that steps are arranged before the portals, then the height of the plinth either becomes less in the interior than on the exterior, or the internal cap must lie higher than the external one.

Instead of the internal plinth is found in most French works, as in the minsters of Freiburg and Strasburg, both a step seat, (thus in the left half of Fig. 840), whose upper edge is enclosed by a chamfer or a stumpy moulding, and on which is set the bases of the rounds as on a common plinth. When the surfaces of the wall under the windows are then animated by blind arches, as in Figs. 844 and 855, then the bases of the shafts of the l latter may stand on the second step rising above the first, as well as generally with the greater projection of the rounds, t the width of the lower step may be divided into two or more divisions. By the unequal heights of the different plinths of the rounds thus received can result especially picturesque combinations. The height of the steps is the usual height of a seat, if they are generally to serve as seats.

External window sill cap.

The window sill cap always has an importance subordinate to the roof cornice, and therefore mostly consists of a simple moulding made in the height of an ashlar, yet there are also found richer forms in which under the drip is formed either a simple cove or one filled by leaves (Fig. 855).

The height of the window sill or rather that of the cap forming the lower part of it is determined by Lacher, so that it shall lie above the wash adistance equal to that between two buttresses. This proportion is perfectly suitable for certain average dimensions, but would be too small for the lesser and wouldlead to considerable heights for greater, and besides by each greater distance of the flying buttresses apart, as then are found in the nave or even in the parallel extension of the choir opposite the polygon, would be entirely illusory and are found disproved in mediaeval works by the most decided variations. Thus the height in kuestion on the chapel of S. Boniface at Fritzlar amounts to 1 3/4 times the distance between the flying buttresses, but on the choir chapels at S. Ouen have scarcely half this width.

The height of the window sill course will consequently be so determined, that in all ordinary cases is attained a height above the floor exceeding the height of the human body. For actually it is still the latter which fixes the distance in question, so that church windows shall exclude the possibility of looking out, opposed to every idea in secular works; thus the underside of the window sill moulding must lie at least the height of a man above the ground. (Our Fig. 840 has the height fixed at 1 1/2 times the height of a man, that we express by a b in the proportion to the whole, and then the window sill is placed about the thickness of the wall above this lower edge, so that then results the inclination of the wash). An increase of this height may be required by certain arrangements occurring in the interior, such as choir stalls, sedilias, by entrances to be arranged under the windows, and further by the magnitude of the entire work, to which is to be denied as little the necessity of a certain indeterminate proportion of the details, since the magnitude of the latter can alone be developed therefrom.

Generally a triple scale will be made the basis of every rationally executed building, particularly that of the proportion of the whole, that of the duration and of the size of the materials, thus the average height of the courses to be used (so t that one may assume three squares connected together and thereby find the separate dimensions from the resulting differences.

On many simpler works is wanting the moulding accompanying the lower edge of the sill course and thereby all horizontal division between the wash of the plinth and the roof cornice. Such is not directly required by the nature of the thing. But since the addition of the wash of an undercut moulding aids the removal of water, an extension of the latter may be required in the width between two buttresses fully occupied by a window and the breaking around the buttresses of the first projection added here. In any case the effect of this horizontal division is favorable by the contrast with the higher proportion of the mullion of the window, and therefore this arrangement is to be preferred to that occurring on certain later works like S. Blasien in Münden, according to which the sill course returns vertically at each side of the windou to a height of about half the width of the window, and then continues horixontally on the

surface of the wall and around the buttress. Sometimes is found such an extension on the sides of the buttress, for a far better reason that a lower position of the sill moulding, in the reverse direction below certain windows, whose sills are thereby m mowed higher to afford the height required for a side doorway under them.

Internal sill moulding.

In the interior the sill moulding has no wash but a groove to receive the water running down on the window, and therefore takes the form like that given at c, and may occur in varied relations with the rounds, when it extends around them (d in Fig. 840) or stops against (e in Fig. 840), or passes under them so that then eest on it. Extension around can be in the same form, or it may be a ring placed at the height of the sill moulding with a different shape (c in Fig. 840). The round can be set directly on the sill moulding if the projection of the latter is sufficient, or so that the projection of the sill course is aided by a corbelling connected with it (as at f).

As an intermediate between both arrangements might be that, whereby beneath the sill mouldingstand single rounds, and on a capital in the height of the sill course stands a triple one corresponding to the vaulting rips. Such an arrangement could result from Fig. 840, if the corbel were replaced by a capital and a round.

Further is sometimes found all three rounds connected together, the two smaller are on the sill course, while that is either b broken around the middle larger one or stops against it.

All such arrangements aid in strengthening the wall beneath the sill course, and the latter may even replace the sill moulding in the form of a simple wash, as in the choir of the church at Wetter (Fig. 843), as then is the latter generally also lacking in the interior of simple works.

We also note, that the difference between the breaking around on the stopping of the various mouldings against the rounds is characteristic of the various periods of Gothic art, in so far as in the older works the rounds formed on the ends of the ashlars are connected with the body of the pier by these mouldings broken around them.

Treatment of the lower part of the wall.

The wall beneath the window has the purpose of enclosing the

room externally and op supporting the window jambs. In a static sense it can further serve to stiffen the adjacent buttresses against each other (Fig. 837), to assist the strongly stressed lower portion of the buttresses, to transfer the pressure to a greater ground area, and by a longitudinal connection of the lower masonry of the buttresses reducing the danger of different settlements in unequal soils. According to the conditions there predominates ona or another of these duties.

In the wall has no buttresses or only small ones, then naturally the greatest stress falls on the lower part of the wall, it receives a comparatively great thickness, which is uniformly continued without deduction and small breadth of the window. But on the contrary for wide windows the buttresses are properly the supporting bodies, and this is reduced the importance of the lower wall, and as previously mentioned above (p. 337), and it t then generally has less importance than the wall arch and therefore can be made thinner than that, or where this will not do, may at least be reduced by recesses in volume.

Recesses on the external surface of the wall are rare, but on the contrary those inside are the more common.

Arcades beneath the windows.

First may the internal strengthening od the part of the wall under the windows, on which the rounds of the wall arches usually stand as in the side choir of Notre Dame of Dijon (Fig. 844), is supported by two little columns adjoining the little columns connected by arches, so that a blind arch results beneath the sill moulding. For a greater width must the number of these blind arches and of columns supporting the arches be increased, and there results those arcades according to the French expression, which in their richer form are in combination of the upper window in the clearstory with the triforium, at least in formal effect are allied to the windows of the side aisles.

In the greater number of the French cathedrals, but in Germany in the minsters of Strasburg, Freiberk etc., is found this mode of treatment, that removes the last remnant of the plain wall surface, and so essentially contributes to the overpowering richness of the whole. Their nearness of these blind arches to the eye permits a richness, a refinement of details, for which was scarcely found opportunity at any other place. Distinguished

in this respect are the arcades of the S. Chapelle in Paris and of Strasburg minster; the latter with a very simple arrangement, so that the capitals passing into the square and terminating c columns connected by strongly profiled pointed arches with inserted trefoils as in Fig. 355, and the spandrels produced between the arches are divided in four panels by inserted circles, the middle one of these bearing a representation of a figure, while the three smaller triangular spandrels are adorned with rich foliage. The effect is even enhanced by the arrangement of the corbelling connected uith the plan of a gallery, decorated by foliage and placed at the height of the capitals on the wall behind (Fig. 855), by which the columns come to stand entirely free. For further concerning this peculiar form, see Galleries, p. 354.

In contrast to the usual arrangement of eoual columns and arches, there alternate in S. Chapelle larger and smaller columns, so that the former being connected by pointed arches form two panelsunder each window, that are again divided by the smaller columns connected with the larger by trefoil arches. As a rule the bases of the little columns stand on a continuous step as in Fig. 845, more rareln directly on the floor as in the cathedral of Chalons sur Marne.

The arches themselves are formed according to all possible lines, as round arches in Fig. 844, as pointed arches, either plain or with cusps as in the cathedral of Meaux, as round trefoil arches as in the cathedral of Amiens, os as pointed trefoil arches in the minsters of Strasburg and Freiberg. In certain German works of the transition style are then found the arrangement also retained sometimes in the Early Gothic, whereby in two recesses beside each other the little middle columns are replaced by corbels. Such an arrangement from the collegiate church of Wetzlar is shown in Fig. 854.

A deviation from the regular placing of the columns produces a variation, if an entrance is placed in the wall concerned, whose width then eoquals about two of the recesses. Thereby is then modified the form of the arch, and in the simplest cases it is replaced by the straight lintel. Such an arrangement is found in the minster of Freiburg (Fig. 845).

Since the columns of these recesses stand in the plane of the

side arches, then is omitted the need of chamber and of placing them in direct connection with the window jambs, and such results only for the middle mullions of four divisions in the way that such stand either over the middle column or the m middle of the arch of the recess, but the other columns are sidewise from the window jambs (Fig. 845 a, where the columns are designated by a and the window jambs by b). On the contrary on later works the endeavor for this relation leads to placing the little columns of the arcade beneath the window jambs, thus to set back a portion, so that the rounds of the side arches pass down before them to the ground, and the backs of the recesses come to be in the plane of the glass. However there can still be effected by the sill moulding intersecting the rounds of the side arches a separation of the window from the blind niches as in the cathedral of Meaux and in Chalons. But this entirely disappears if the sill moulding intersects the window jambs, and the latter exteods to the ground replacing the rounds of the b blind arches, as in the transepts of the cathedral of Meaux.

Blind arches without windows above them.

Sometimes these blind arches are also found without connection with windows above them, as in the vestibule of Freiburg minster. In this case the sill moulding naturally vanishes over them, since the horizontal termination loses its importance, but then the gable is best suited to the nature of the pointed arch for covering it, by which its apex is loaded and its upward force is restricted. Likewise the stability of the columns will be increased thereby, which in Freiburg occurs from placing a figure, and we thereby pass in this ornamental form here to the expression of a ground principle of Gothic architecture.

Blind arches with narrow windows.

When the window does not entirely occupy the space between the buttresses, then blind arches extending the full width at both sides of the window, plane wall surfaces produce a heavy effect. (Indeed in Freiburg this arrangement is found connected with the plan of a choir aisle, to which we shall return later). To avoid this evil result the blend arches may also be repeated above the sill moulding on the wall surface, or may be omitted below it, and only for the width of the window and either in the thickness of the jamb or within the depth of the member extended to the

ground is found in certain later works also without blind arches, indeed in the interior as well as on the exterior, so that in the last case the inner surface of the wall remains plain.

A particularly rich example of the last kind is found in the choir of the church at Freiburg-on-Unstrut, dating from the 15 th century, where directly beneath the sill moulding on whose wash stop the jamb members, it is enclosed by the same arrangement having the same width as the window, and for-sided recesses occur having panels decorated by reliefs, while the outside members of the jambs directly below the sill moulding form a series of suspended bound arches with cusps, that in a manner form a canopy over the reliefs.

Simple blind arches.

As a substitute for all such richer forms are then usually found on these walls simple blind pointed arches lacking all direct connection with the windows, as in the choir aisle of S. Gudule in Brussels and the transepts of the church in Wetter, and farther in many N. German brick churches.

Arrangement of windows.

Height of the window.

For the height of the window arch is determined a maximum, so that for its body may remain beneath the side arch. This condition results of itself, if the window entirely occupies the space between the buttresses, and hence the window and side arches are either concentric or coincide, as assumed for the middle w window in Fig. 840.

With a smaller width of the window, the concentric arrangement of windows and side arches will then only remain possible if the proportion of the width is such, that no extremely pointed form is compulsory, but is necessary in no case.

A minimum height of the window is determined by the common ground lines between window and side arches. Thus the heights of the side windows are determined in Fig. 840.

On the ratio of the height of the window to the height of the wall beneath the sill moulding it can only be established, that the former shall predominate, as based on the nature of the matter

Maximum width of window.

It has already been shown how the greatest width of the window results, so that its jambs lie directly at the buttresses so t that their sides form the jambs, from which start the arches.

Now since for oblong bays the ground lines of the stilted window arches come to lie at a certain height, to which the cross arches are pushed up in a notable way, then the window arches or a strengthening thereof is furnished by the proper side arches, here extend exactly like vertical surfaces forming the edge of the compartment. The prespective view (Fig. 846) shows this arrangement at b, that is found especially bold in the hexapartite vaults of the choir of the cathedral of Beauvais, whose arrangement is shown in Fig. 847. Here the side arch is cut away at one side by the vertical lines bordering the halfway rib, while at the other side the line of intersection is visible behind the cross rib omitted in our Fig. Accordingly the outer rib of the pointed arch on which rests the compartment no longer forms a complete pointed arch, but only a segment, so that the compartments intersect those surfaces at a very obtuse angle.

This otherwise scarcely visible peculiarity is found in the choir of the cathedral of Toul, whose arrangement is shown iu the elevation and plan in Figs. 850, 850 a, executed for the p purpose. As shown by the plan, the buttresses of the choir ending in the half decagon are moved so far inside, that above the window sill an opening extends through them, and before their tops project the shafts bearing the cross ribs a, while the anges b and this pier subdivided by the inserted shaft receive the side arch continued over this passage as a tunnel vault. On these internal buttresses lie the jambs of the window, that are turned as pointed arches as shown by the elevation, but thereby the external line of the before mentioned strengthening arch and f further the tunnel vaults between the piers are required by that broken line of the pointed arch, whose starting therefore lies high above the capitals of the rounds c found in the ground line of the cross arches of the choir in Fig. 850. But since the span of the cross ribs in the middle square preceding the choir is far greater than in the polygonal choir, there results for the former a far greater height with equal height of the crown and a similar form of arch, and thereby the height of the capitals in the transverse aisle as well as on the pier of the choir is placed so much lower, and on which rest the cross ribs resisting the entire thrust of the ribs of the polygon.

At the latter height terminate all choir piers in capitals, on which rest the pieces forming that difference like independent piers.

Side and window arches.

If the windows extend from pier to pier, the form of window arch is determined by the concentric line of the side arch. But where the entire construction causes, that the crown of the arch lies very near the horizontal top of the wall, particularly with equal heights of all the crowns of the vault, with a pointed form of window arch and even for these equilateral, the upward force of the arch does not appear alone to break this horizontal limiting line, but in many cases actually produces this effect. Hence in this case it is better to place the crown a little lower, and to construct the arch with a smaller rise (giving it the form of arch with centres given by dividing the base in 4 parts). Fig. 849 will give the section in Fig. 849 for the eastern side, only with the assumption of a pointed form drawn instead of Fig. 849 a. On works executed with greater richness are then found for loading the apex of the arch the crowning of the window arch by a gable, first occurring on the S. Chapelle in Paris. Further see former p. 342).

Further the pointed form of the side arch, that also requires for it again a pointed arch (even though excentric), or by the arrangement of several windows beside each other in the side of the same bay, at least a grouping to rise toward the middle. Such is obtained by the arrangement of two windows, as found in the Regensburg cathedral and the church of S. Peter at Lübeck, by the addition of a round window betwiin the two window arches and the side arch, by the plan of 3 windows beside each other, as found on Early English and certain German works, with a greater height of the middle window.

Conversely in many French works, as in the transepts at Amiens, the arrangement of a wheel window for the entire width refers to the semicircular form of the side arch.

Independence of side and window arches.

The necessity but not the validity of the pointed arch or of the culminating form of the window vanishes with the vault itself, and likewise with the assumption of that rib vault represented in Fig. 96, in which the compartments are replaced by stone slabs. Therefore are found in the interior of the Freiburg tower, from which the construction is taken, between each two such ribs are three pointed arched windows beside each other.

The same mode of construction found a somewhat changed appli-

application in the older churches of Burgundy (Fig. 848). Particularly here the window wall between the buttresses is moved out so far, that within it passages lead through the latter. The side arches of the vault then became free af the wall lying there on as freely projecting arches like the other ribs, and over the junction of the compartment are leveled by a wall built on them and connected with the window wall by utone slabs laid thereon, which accordingly form a horizontal ceiling on t the width of the passage, and their upper surface either forms the channel for water or receives it; Fig. 848 shows this arrangement for Notre Dame at Dijon. There a is the side arch, b the internal buttress with the passage, c the stone slab laid above, d the window wall, that is opended by 3 pointed windows of equal height. Likewise a rectangular form of window would be suitable here, with a covering of sufficient strength to support these slabs. In Viollet-le-Duc is found an example taken from S. Germain des Pres, where in the rectangular windou is inserted a great pointed arch divided into 4 panels by large and small mullions, and the spandrels formed between the latter and the rectangular enclosure are again filled by inserted trefoils, the latter sufficiently strengthening the horizontal covering.

A particularly ingenious and splendid application of the same construction is found on the rose window of the Strasburg minster. The passage here lies outside; the window proper recedes to the place of the side arch in Fig. 848, while the window wall in the same Fig. is replaced by a circle with suspended arch inside, turned between the buttresses, floor and the ceiling of the passage, and the spandrel between the latter and the sides of the square is filled by open and beautifully treated tracery. Now conceive in the example represented above, that the window wall as in Fig. 848 is set in the outer side of the passage, t then would the spandrels be perforated in the same way and glazed, and thus the enclosure of the circle by the square would appear gust as organic, as that by the pointed arch according to the usual form of vault.

Jambs and mullions.

As previously stated, the mullions in works of the 12 th century assume a greater, and consequently the jambs a lesser importance. We exhibit it on the plan of the window of the choir in Wetter given in Fig. 851, where the thickness of the mullion

amounts to about half of the wall, and the jambs consist of simple splays. . The latter form is that most frequently occurring in the simpler works, while richer jambs are formed by rounds placed in the right angle formed in the projection of the wall. Then either the capitals of these rounds receive the members of the arch in another ground form inscribed in the right angle of the ashlars, or the shaft continues in the arch as a round. The members of the form commenced by these little columns then continue on the mullions, and thus become more complicated in the arrangement of large and small mullions. Only in Strasburg the difference between the mullions vanishes, since the larger only consist of two smaller ones placed beside each other (Fig. 855 a at b).

The thickness of the window jambs and mullions is determined by Lacher at 1/3 the thickness of the wall for each. In other places in the same manuscript appears to be given for mullions 4/10 the thickness of the wall, as also assumed by Hoffstadt, the thickness of the jambs then being 3/10. Both sizes correspond to most German works of the 14 th and 15 th centuries, where the desire for rich combinations of tracery and too slender forms of mullions led to the small size of the latter. An example of this kind is shown by the square in Fig. 841.

Even in cases where the window occupies the entire width of the bay, are sometimes found such rich members on the arches entirely or partly intersecting the sides of the buttresses. Such an example from the choir of S. Ouen in Rouen is shown by Fig. 841 b.

Sometimes as on the upper windows of the church at Haina, (Fig. 851 a) the mullions connected with the little columns lie nearly in both faces of the wall, and are separated therefrom only by a cove, so that they occupy the full thickness of the wall. Then the window arch is enlarged externally by a projecting drip moulding of concentric form, which in the ground line of the window arch is returned horiqontally and continues a short distance, then goes vertically downward and again horizontally around the the buttress, forming the border by its offset

Hood mouldinm.

Moreover there occur here members enclosing the arches and projecting from the face of the wall, that generally occur on the works of the 13 th century, a very effective means for increasing

the importance of the arch and animating the surface of the wall.

As a rule these hood arches take the members of a simple drip moulding, yet on French works are usually cavettos containing rosettes or foliage.

While they form the window arches in Haina, they are certainly found in other places as protections of these, so they are separated from the members of the jamb by a plain band.

Instead of the rectangular return, which is assumed there and that results from the proportion of the height of the beginning of the arch to that of the ground line of the window arch, they usually continue horizontally in the latter and stop against the buttresses, or they rest on corbels beside the window jambs at the same height.

Passages.

For the maintenance of the different parts of every building and the reparaaion of injuries occurring, easy accessability is of the highest importance. But more than elsewhere will this be necessary at the windows, and on Gothic churches of the earlier system it is provided by the arrangement of passages at the height of the window sills, and that can be constructed in the most varied ways.

Structural principles of the passages.

The modern custom would be, assuming otherwise the adoption of the system of Gothic construction, that lying nearest and s shown in section in Fig. 852, according to which the passage c consisting of a continuous balcony supported by corbels, that leads outside the vaulting shafts standing at the face of the wall. In Gothic art is found in its right endeavor to obtain the greatest effect with the least means. It then sometimes utilizes the projection created for the passage to reduce the span of the vault, accordingly a lesser height and measure of resistance sufficing for the entire construction. It employs detached columns, that stand in the outer face of the passage, and connects these with the wall or rather with the buttresses by a strong lintel, whose end s forms the springing of the rib, and which is supported by corbels from the face of the wall, but turns a tunnel vault over the width of the passage, which at the same time also forms the side arch for the middle vault, and s supports the columns either by strengthened corbels or by a pier extended from the ground. With the adoption of the latter cons-

construction we reach the system of the internal buttresses furnished with passages at the height of the window sill. Below the passage the piers in the simplest cases are again connected by arches of tunnel vaults, on which lies the floor of the passage, while the rounds either extend up from the ground or are corbelled out from the face of the pier at the height of the passage. (Fig. 353). The last arrrangement is found in the choir and transepts of the church at Haina, and is entirely in place, since the corbel bonded to the pier by the great and concentrated weight of it affords a sufficiently secure position.

Stability.

In Haina (Fig. 833 a) and in the side aisles of the Freiburg minster the piers before the passage are thin but very wide. The adoption of such great breadth of the pier is attributed to the view, to offset the weakening caused by breaking. Yet this weakening exists an a far less degree than it appears.

If we provisionally assume hhe pier in Fig. 853 to be solid, then with insuffieient strength of it are possible two results. the first would be a bending of the wall outward, and then occurs if the resistance opposed to the thrust of the vault by the overlying courses by friction, assisted by the adhesion of the mortar is insufficient because of the size of this area or by too small loading. The second effect would be an overturning of the pier about the foot of the front face.

The first of these effects by bulging outward is only to be cared for in regard to the thrust of the vault by directly applied courses, that according to the course of the line of pressure lies at 1/5 to 1/3 the rise above the springing of the vault. Hence it follows that a fracture of the pier or rather of the springing of the arch at the so determined height or above is certainly impossible, but below this a bulging of the wall cannot occur. We here add the example given in Fig.854 from the S. transept of the collegiate church at Wetzlar, where above the capital of the pier is found the fracture extending through the springing of the arch, that scarcely reaches the limits of possibility.

But the result of overturning the pier can be aided by the f fracture of the pier only so far as the feared pivot is moved back from the foot in Fig. 853 toward the point c, whereby the weight of the overturning mass is reduced by the volume of the fracture and of the standing internal pier. To equal this reduc-

reduction is only required a very small increase in the depth of the buttress, since as already stated, its depth acts in about the square proportion.

Hereby is explained the width of that internal pier in Haina, that by the mass pertaining to an earlier design, and not by the strengthened lower wall strength by buttresses, they were prevented from lengthening the upper buttress, a means that certainly could not occur in Freiburg. Further on the stability of passages, se later p. 358.

Passage in Strasburg minster.

In the most perfect form appears the arrangement of internal passages at the windows of the side aisles of the Strasburg minster (Figs. 855, 855 a). As shown by the plan, the internal detached pier is entirely enclosed by the three rounds of the cross and diagonal ribs extended from the floor and the two at a standing on the floor of the passage, which support the free side arch.

The width of the passage is not as in Fig. 853 covered by a simple tunnel vault, whose richness is increased by that of the compartment d, but extends over the latter by an extension concentric with the side arch, that is received by the arch b extending lengthwise on the face of the wall. Since further the i interior opened buttress covered by the rounds, required for thrusts of the vaults of the side aisles, aside from the buttress system of the middle aisle, to have strong external buttresses, rather than to strengthen the latter, thus their width was reduced ao the least dimensions, and its face f recedes far behind that of the rounds of the side arches. Thus the entire arrangement of the boldness of the covering of the passages shown in Fig. 848 by horizontal stone slabs is nearest, and the advantage is peculiar to it over the latter, that it avoids the unquiet effect, produced by the latter by the onesided abutment of the compartment against the wall set on the side arches as at x.

In Strasburg the floor slabs of the passage are supported by the blind arches mentioned above (q in Fig. 855). Since further the window jambs do not directly adjoin the buttresses, then must the jambs be carried down at least to the sill moulding, and thereby as well as by the plan of the passage occurred an unnecessary breadth at the height of the sill moulding. Hence the thickness of the wall is not alone reduced by the corbellign

already mentioned above, but also by the bold membering of the sill moulding, and yet more because the depth of the jamb still projects beyond the extreme line of that moulding, so that the bases of the columns project beyond its edge by a horizontal bottom surface h.

As a rule the passages lack railings, but at the same time the window wall affords entire safety. Only in Freiburg was the outer edge furnished later with a gallery of perforated Late Gothic tracery, which is then wrought in relief on the fronh surfaces. of those internal buttresses to the rounds, but being loaded here by the upper mass of the wall, it produces no pleasing effect. Besides the gallery conceals the lower part of the window, and would be better if replaced by iron rods reaching between the piers and with ends let into them.

External passages.

We have so far only mentioned internal passages, but they can also be arranged externally in the same manner, there leading through the buttresses as on the side aisles of the collegiate church of Wetzlar, on its choir polygon and on the church of S. Elisabeth at Marburg. However it would be nearest to place it against that side of the window occupied by the glass.

Since very generally in the arrangement of two rows of windows over each other, the lower was glazed from the inside anf the upper from the outside, also accordingly the position of the p passage differs. Those two passages are found on the church at Wetzlar, the lower being inside and the upper outside the window. (Figs. 856to856 c). The entire design bears a very primitive stamp, so far as both passages as shown by the section in Fig. 856 a, lie obliquely beside each other and thus require a width, that is indeed afforded there by the unusual thickness of the wall and priers. Thus the utility is further lessened, to be derived from a continuous corbelling or by arches turned between the piers for the arrangement of the passages, and therefore recourse is had to a series of unusual expedients.

We first call attention to this, that the faces of the rear walls of both passages a and b lie over each other (Fig. 856 a). Accordingly all projections from the window mullions must be omitted externally to avoid a reduction of the width of the passage, but the glass itself is set so much inside the face b, that on the middle mullion was yet possible the arrangement of the

outer calking fillet was possible. The middle mullion is then expressed externally by no moulding that receives its full depth inside, by which it extends down on the face a, and rests on a corbel at d about 3 m above the lower passage; but sinci it likewise projects inward from the face b of the wall, it must stop on the sill of the window forming an internally projecting moulding g.

The lower passage leads through both these walls. Before the upper passage lie externally the piers f without capitals in F Figs. 856 a and c, from which stone beams ornamented by leaves extend to the wall, that serve as bases for the three tunnel vaults turned over the external passage between each two buttresses. By the arrangement of these piers and vaults is at the same time removed the otherwise unavoidable effect of all external members on the window mullions in a very happy manner.

This arrangement transferred from the Early Christian and Romanesque periods, of detached piers or columns as supports of certain tunnel vaults (dwarf galleries, etc.) is however peculiar to the passages of the transition style, indeed being often turned toward the interior and connected with the windous, so far as that a window is found beneath each tunnel vault. In Still Romanesque treatment it is seen in the middle aisle of the minster at Bonn, where the windows are only placed at the height of the side arch, and therefore beside this arcade remains the surface of the wall, behind which the passage extends and opens to the interior beside the windows.

A nearly allied but far more complicated design of double passages over and yet beside each other as in Wetzlar is found in the cathedral at Besancon, where the window utory is connected with the arrangement of the triforium, and to which we shall r return later.

Preferable in this respect to this arrangement beside each other are the passages placed at different heights vertically over each other. Such a design originates in the simplest way when both passages are placed at the same side of the window wall. Such an example is found in the S. transept of the church at Wetzlar as shown in Fig. 854, so that the floor of the upper passage only temporarily in case of need connected the openings in the springings of the vaults by means of beams laid across, that could be removed afterwards. At The least we might find in

the reason for the arrangement of these openings.

A permanent and actually built arrangement of double passages fully requires that of a double row of windows, such as found on S. Elisabeth at Marburg, where the passages lie on corbellings extending from one buttress to another. In the same manner can they also be supported by arches turned between the buttresses. These can either be continued as tunnel vaults for the width of the passages, or be free for a certain distance and bear slabs laid to the wall as in Fig. 848.

External and internal passages are connected.

In this arrangement also lies sometimes the simplest solution of the problem of placing the passages at opposite sides of the window wall, namely that these arches alternate in place with the lower windows, and hence the upper windows come to stand over the arches. Thereby the upper passage lies outside and the lower one is inside, the floor of the latter being either borne by cross arches as in Strasburg, by blind arches or lastly by corbels, niched by continuous corbelling as in Marburg, or by separate corbels connected by arches as in the churches at Gelnhausen and at Wetzlar. The form of the upper window can harmonize with that of the lower as on the church of S. Elisabeth at Marburg, or may differ from it.

Likewise here the system of construction of the passage, that just in the same manner as we have already stated concerning t the side aisle on p. 351, first determines the choice of a pointed or horixontally covered window form. Generally for small heights a diversity in the two rows of windows is more tasteful, rather in the way that the lower division consists of two or t three windowu of equal height, the upper being composed of one divided by mullions and covered by a pointed arch

Doubled row of windows.

In all cases with a great development in height the Early Gothic arrangement of a double row of windows is to be preferred to the extremely slender treatment of the window in the later period, since besides the more tasteful effect it affords better access to the windows and a more favorable longitudinal stiffening (p. 338). Indeed men had become accustomed to regard the slender windows as a necessary product of Gothic verticalism, indeed as the only expression of ecclesiastical charcater in t the measure, that it is accepted in even church buildings in

Conversely the design of the church of Marburg is certainly from Romanesque reminiscences anf those of the french single-aisled choir and transepts, to which we have already had to refer as well as to the choir of Regensburg calthedral, only thereby an entire unity of effect of parts in several aisles, or to approach the magnificence of the arrangement of a choir with aisles, or finally to make possible a more perfect circulation, led to retaining the subdivision of the height of the nave.

To this it would be opposed, that the last could be expressed by the arrangement of stairs, that moreover the division in height of the choir and transepts does not always harmonize with that od the aisles. Here we shall only refer to the cathedral of Noyon in which in the middle aisle above the side aisle and thus directly above the side arches is a vaulted gallery, over which is the triforium and above the last is found the clearstory windows, while in the transepts the division in height is changed, so that over the height of the dividing arches and t thus at the height of the floor of that gallery is the triforium, over the latter being a double row of windows placed over each other, so that before the lower and inner passage is found and before the latter is an outer one.

But the intention is further to establish a unity between the different parts of the same work required by no internal reasons, just as far from the nature of Gothic art as the other, to simmulate an effect corresponding to an entirely different conception.

It must be further noted here, that when verticalism reaches an enhanced expression of Gothic construction, this nowise suppresses horizontalism, and that on the contrary the endeavor to elevate the former principle at the cost of the latter so as to predominate alone, even form the weakness of the later works, which by the opponents of this art is erroneously represented as a necessity thereof.

If we now pass to the Late Gothic arrangement of windows occupying the entire height above the sill moulding, which height is often to increased, that the proportion to the width is scarcely intelligible, then must we make prominent the defect, that this defect is so exclusive and injurious to all other parts to be pleasing, and therefore has already produced many ugly arrangements. It is further unfavorable to the effect of the glass, both for the adoption of a white or colored pattern from the

necessity of innumerable repetitions, as well as with the representations of figures, and in the later peroids of Gothic art it led to those painted canopies like towers over the figures, that strictly taken can only be regarded as filling spaces.

But further that excessive height of windows also creates a need for their accessability by passages. In the recognized requirement of the latter is to be sought the proper structural ground for the Early Gothic design of a double row of windows, whose effect then is an art form as shown by the existing examples, at least as not inferior to the later arrangement. It is in the nature of the matter, that this design in general like every one, is connected with a certain relation of magnitudes, and requires a careful gradation of heights to widths. The minimum dimensions that permit a double row of windows must lie within a width of nave of 8 to 9 m, where the height amounts to about twice the width.

For this proportion we try in Figs 857 to 857 c the design for a bay. We make there the length of the bay, a b in Fig. 857 c, equal to h f the width, the entire width of the pier a c equal to 1/4 the diagonal with regard to the openings, and then assume a sufficient thickness of the pier and a corresponding location of the outer face of the lower wall through the point e. Then in the internal elevation of Fig. 857 the height f f′ = 4 a b and accordingly the rectangle a b a′b′ is determined as well as its diagonal and the lines a f′ and b f′, and further the line a i is drawn as diagonal of the square, so that the different intersections of these lines indicate the heights k, l, m, n and

Likewise in the external elevation of Fig. 857 b the height a b is determined by the width between two buttresses, the height c d by the diagonal of the square described with this width, the height c g by the diagonal of its cube, but the height e f by the sum of the widths a b and c d. The cross section of Fig. 857 a then shows the construction of the whole, in which over the lower windows are turned two of the tunnel vaults supported by a middle column, and the arch of the upper window inside is strengthened by the side arch, outside by the arch turned between the buttresses.

The predominance of the upper windows over the lower is first required by the necessity, that the opening through the buttresses lies below tte point of application of the thrust of the vaul

Therefore at most an equality of both divisions is to be obtained, but not the reversed proportion.

When we have explained here the arrangement of a double row of windows first in relation to single-aisled churches, what is said is likewise true for the side aisles of three-aisled churches, but the entire arrangement finds renewed application in connection with the design of double side aisles over each other, to which we shall return later.

Effect of openings on stability.

An abutment with great openings always produces the impression of great boldness, in some cases even a certain insecurity. In famt may be conceivable openings at unsuitable places, and on the other hand if rightly employed may lead to surprising boldness, such ar are shown by the old works and proved by an examination of the stability.

Permissibility of the opening. .

In an abutment mass, that must resist side forces, only occasionally comes the question of strength of materials, while the greater part of the materials usually serves only as a heavy mass to increase the stability. It is evident that first openings may be made in these more weighty parts, so far as they do not cause an unfavorable arrangement or too great reduction of weight; with correct use they may even serve for a better distribution of the weight or a saving of unnecessary masses.

In some circumstances are possible openings even in the more strongly stressed parts, they can comple there a desirable location of the pressure, and sometimes also remove the statical uncertainty concerning the assumed distribution of the pressure.

If it is desired to follow the entire course of the pressure from top to bottom of a perforacted abutment or a pier with an opening, then is sought in the ordinary line of support (p. 141), where the vlomue lost by the opening is also omitted in the calculation of the weights. If the line of support corsses an opening, there is nothing distributing in this. In such a place the resultang must be divided, so that a corresponding portion of the pressure is transmitted in the masonry at each side of the opening, whose magnitude and direction cayn be found (See below).

Since the safety of the structure must not be affected by the opening, two requirements are to be established, first that the danger of overturning is not increased, and then that the edge

pressure be nowhere too great, or besides the latter requirement, also that for preventing the opening of the joints, the resultant must remain within the kern of the cross section.

Fall by overturning.

Safety against overturning. An abutment of the form represented in Fig. 858 under the influence of a side force H is firts inclined to overturn about the lower angle A. But if a higher bed K L above occur great recesses or openings, the dangerous angle may change upward to K, the rotation indeed occurring if the moment of stability $Q \times a$ becomes less than the overturning molent $H \times c$, where Q is the resultant of all weights existing in and on the abutment, a denoting its horizontal distance from the pivot angle K. The overturning is illustrated by Fig. 858 a and causes a movement of the centre of gravity S (Fig. 858) in an arc struck from K to S_1, so that the entire volume G is to be raised the distance h_1 or T S_1.

Fall by overturning the wall of the passage.

Besides overturning because of the existence of a recession, overturning occurs in the manner exhibited by Fig. 858 b. The larger part K C D R of the wall lying beside the opening (Fig. 858) is rolled or tipped until the angle D lies vertically over K; from thence the mass already overturns of itself. The centre of gravity s of the part K C D R then passes in an arc described from K to s_1, its weight G is thus raised a distance h_2, and all the masonry lying above C D is at the same time with the angle D is raised a considerable height h_1.

Denote the weight of the upper wall above C D by P and the weight of the supporting wall K C D R by G, then for this position on edge is to be performed the work $P h_1 + G h_2$.

On the contrary the work in simply overturning (Fig. 858a) is:- $(P + G) \times h_1$.

According to whether the first or the second of these expressions is least, is more easily to be feared a tipping (Fig. 858 b) or an overturning (Fig. 858 a).

If the weight of the supporting block is relatively small in comparison to the upper wall, then can be produced a much simpler indication; draw about K the circular arcs S S_1 and D D_1 and measure the ordinates h and h_1. If h is smaller, tipping ((Fig. 858 a) will most readily occur; but if h_1 is smaller, the

rolling (Fig. 858 b) is to be feared. Thus the arrangement of an opening cannot be regarded as an unstable place in the entire structure, so long as the distance h_1 is greater than h. T This condition will frequently permit the opening to rise to half or more of the height of the wall, and on the other hand openings are less to be feared the lower they are and the wider the supporting block beside them.

Distribution of the pressure to the two walls.

Allowable stress; position of the pressure in kern. When the safety of the mass of the body against the danger of overturning is determined as in the preceding, there is assumed no limit of strength of the building materials; since such does not exist, there actually occurs a crushing of the dangerous angle before the commencement of the overturning. Therefore the greater requirement is to be established, that in no place and particularly at no angle may the pressure on the material exceed a limit judged to be allowable. Besides for most cases is also the requirement that the resultant pressure shall not leave the kern of t the cross section. Which of the two last requirements is most stringent depends in certain cases on accessory conditions. The question of distribution of pressure in general has before been so fully treated (p. 137 to 148), that it only remains here to consider the course of the force in the present entirely definite case of an opening in a wall.

There is first sought the magnitude and location of the resultant for the horizontal bed above the opening (Figs. 370 and 371 on p. 140), and then this is resolved into the components that continue in the masonry at both sides of the opening. The analysis is executed for four different cases in Figs. 859 I to IV

• Some special cases.

Fig. 859 I. The resultant R is vertical and the supporting w walls are rather thin. If R lies in the middle between the two walls, each would receive half the pressure. But since in the drawing R lies more to the left, then would the larger component fall there, and R would be distributed to the two walls, j just as a single load on a beam is resolved into the two pressures on the supports, the components being inversely proportional to their distances from R, and can be obtained graphically as follows. Assuming the points of application of the components at A and B at the middles of the supporing walls, the magnitude

of R is laid off as the length C F, and the lines C A and C B are drawn and with these and the diagonal C F is found the parallellogram C D F L. Now drawing a horizontal through C, the d distances G D and E J give the magnitudes of the components sought.

The assumption that the points of application of the components A and B lie in the middles of the walls, can only approximate correctness, since the different locations of R and the varying thickness of the supporting walls and that may produce dangers in these as well as in the construction chosen to cover them. To decide with approximate accuracy in special cases, as for the position of R near one side and greater thickness of one or the other of the supporting walls, one must realize that the resultant R does not act at a single point, but that it is merely a comprehensive expression for the forces widely distributed in the area, as pefore illustrated by the representations of stresses in Figs. 375 to 377 .s well as Figs. 383 to 385.

Fig. 859 II. The resultant R is oblique with eqaal thickness of the supporting walls. It can be assumed, that the components are parallel to R and that the points of pressure A and B are given, so that the resolution is assumed as in Fig. I. The component lying nearest R will again be greatest. Accordingly the components are composed with the weights of the walls G and G_1, project below as M and N, and can again be combined in a resultand R_1 if required.

Likewise here the location of the points of pressure A and B are not to be fixed with certainty. As in vaults (p. 47) if a favorable effect of the plastic mortar is counted on, it is assumed that with correct construction it will be endeavored to keep the components as nearly as possible in the middle of the supporting walls, so that the point A lies about as far to the right as m lies to the left of the same. If one proceeds in this assumption, he can regard the supporting wall as sufficiently strong, so long as it is possible to locate the component in it, that if the pressure is nowhere too great, or also that the pressure may everywhere remain in the kern.

The direction of the components parallel to the resultant also occurs in some circumstances, and cases may occur in which one component is quite or nearly vertical, while the other is so m much more inclined (Fig. 859 III), indeed by vaults with strong thrusts they may be directed outward between the supporting walls.

It is to be particularly assumed that walls of unequal thickness, that with the otherwise corresponding construction the component is steeper in the thinner and flatter than in the thicker wall.

Fig. 859 III. With an oblique direction of the resultant, there is a thicker supporting wall at the outside but merely a t thin one at the other, though a sufficiently strong support. O Only a vertical force can be assigned to the latter. To find t the components a vertical is drawn through B to intersect R at O. From O is drawn the line O A and by the parallelogram the force R in the direction O A is resolved into its components, with which are combined within the walls their weights G and G_1. If the force passes unfavorably in the left wall, the construction can be repeated by moving A.

The actual position of A naturally depends on circumstances, and it may be strongly influenced by the length of the support at the right, for the most unfavorable case occurs if the support is too long (Fig. 859 999 a). Then the upper load chiefly rests on the angle C, and the transfer to the oblique force is thus generally impossible. A condition of rest can occur again only by the breaking off of a piece of stone at C, or after the sliding of the upper mass to the left, whereby the supporting wall rotates so far that the inner angle D lies above and with the adjacent parts od the surface receives the pressure.

Fig. 859 IV. The locations of the support and supporting wall are exchanged, otherwise being as before. The resolution of the forces proceeds with the sole exception that the intersection O is moved downward. If the intersection lies too far, this may be helped in a different way from the former case. R is first resolved into vertical and horizontal forces V and H. V is resolved into its vertical components acting at A and B according to Fig. 859 I. The support lying at the left will receive no p part of H worth considering, and therefore H will be entirely supported at the point B as B J. B J and B E then combined give the force B E in the stronger wall at the right.

Changing the load.

Where the loads vary, as where the wind exerts an influence, there will vary the magnitude of the resulting pressure R, and likewise its direction varies, there must naturally exist a sufficient safety for this case of loading, and it suffices to investigate for the two limits of R.

Mode of construction.

Narrow passages are best covered by stone beams or slabs of strong and tough stone; where this cannot be used, by corbelling and also by vaulting in special cases. If metal ties are generally employed, they will be in place over and below the openings.

That a proper transmission of force may occur, as clearly results from the previously described examples, a very careful execution that includes oversight of all important conditions of transmission and pressure is required for just those points. Caution is particularly required if at one side of the passage are employed tall columns of a single piece, while the wall at the other side is built of separate courses in shrinking mortar. What injurious influence can be exerted by too long columns, aside from their too great loading, is illustrated by the little sketch in Fig. 359 III a. That such particularly bold construction in mediaeval works has chiefly lasted very well shows, that the old masters in the execution correctly supervised all important requirements.

Arrangement for removal of water, gutters and gargoyles.

Fall from edege of roof.

The simplest and most common removal of water in Germany is that the water simply drops from the projecting edge of the roof, and by its overhang is prevented from flowing down the wall surface. The efficiency if this protection increases with the projection of the roof made by wooden construction.

If the plan if an always limited projection of the roof permitted by a stone moulding without a gutteris imperfect, yet it may be required by limited means, and it either assumes the form shown in Fig. 360, where the edge of the roof is directly over the face of the moulding, or it is according to Fig. 361 a board nailed on the projecting ends of the joists, that forms above the moulding an oblique surface increasing the projection.

Yet a more exact investigation shows many works in their present condition lacking a gutter, yet such was originally intended and either has already disappeared in the erection of the roof or in consequence of later alterations. Generally appear on simple buildings, especially if secular, that also gutters of wood or metal formerly existed.

Metal gutters.

Where suitable stone was lacking, the gutters were made of

metal. Yet many modern designs though impereftc in many respects, have an advantage over a construction occurring in works on the lower Rhine, where the gutter is in a manner prepared for by a board fastened on the beam ends in the external face (Fig. 862). It consists of a wooden bottom in the given case and a low parapet formed by boarding a low parapet with connecting beams a. The latter is then slated externally beneath the lowest slates of the roof and bent over the top of that parapet. These gutters are improved if desired, that if leaky the water is so led away that it cannot wet the beams. Particularly favorable are the f freely placed gutters above a wash on separate projecting stone corbels, as executed on the most recent Gothic brick buildings.

Stone gutters.

Stone gutters are formed by a channel sunk in the top of the cornice slab, then if necessary with a slight fall of the bottom toward the discharge.

With regard to this channle, its depth must be reduced as much as possible to avoid weakening the stone, but on the contrary the width can be made as wide as possible. The sides may be formed by slopes (Fig. 863 at a), or may pass into the bottom by curves.

In the simplest case the top of the gutter lies directly under the bottom of the beams, the edge of the roof being either placed over its edge or better laid above it. In any case the beam ends and sides between them are to be protected from the water. The best plan is to raise the wall behind the rear side of the gutter, whereby the beams are raised or a low wall is built.(Fig.8

With a more complete construction the edge of the gutter has a balustrade wall or a so-called roof gallery, that in the simplest case would be built later outside the slated gutter, so that its outside continues the slope of the wash and would be covered by a scale-like decoration of the surface.(Figs. 863, 863

Gutters with parapets.

Much richer is the arrangement of tracery balustrades(see later under Tracery); the design requires sufficient width of the upper surface of the gutter for setting the slabs, where the separate pieces are either doweled or fixed by tongue and groove as in Fig. 864. It is preferable in both cases to strengthen the sides of the tongue, and therefore to leave the gutter a projection beyond the face of the balustrade, finished attop

by a wash. The separate parts of the balustrade are accordingly connected at bottom by the gutter in which they are inserted, and at top by the cap laid on them, whose joints must therefore alternate with those of the balustrade. According to the earlier mode of construction the cap of the balustrade is cut on the s slabs and so this connection vanishes and is replaced by dowels inserted in the end joints. The projection of the cap must then be cut at the top of the balustrade and remains at its bottom as a plinth.

Now if we take as the bearing for the beams a width of 36 to 40 cm, the same for the bottom of the channel, and for setting the balustrade 16 to 18 cm, there results for the upper surface of the wall a necessary width of at least 90 cm, which exceeds the dimensions required for the window wall, on which the entire construction depends, and therefore may require it to be increase

This can be effected inside by corbelling over the top of the compartments, or by an arch about concentric with the side archl externally by those frequently mentioned arches turned between the buttresses as in Fig. 857 b, but most simply by increasing the projection of the cornice. Later will be given various profiles of cut stones producing the same. The upper edge of these members, at least in richer treatment, receives a lower support like that of the bell of a capital, by very varied forms of clever foliage supports, which at the same time compose the most effective ornamentation of the entire cornice, and whose ends generally extend above the face of the edge. As on capitals, they are sometimes connected with a lower row of leaves inserted between them, and are sometimes replaced by these. In Fig. 864 is given the entire construction of such a cornice with balustrade.

Gutter on corbels.

On Burgundian works, those at Notre Dame and the cathedral of Dijon, this piece of cornice is replaced by separate corbels supporting the gutter. On the collegiate church at Colmar this arrangement in larger dimensions is found under the gable of the S. transept, so that here a formal balcony results with a tracery balustrade strengthened by three pinnacles, its bottom slab be ng supported by strongly projecting corbels. Yet these corpcls according to the real purpose are far apart and the corbels

are set beneath the joints, in contrast to the more ornamental and closer placing on modern Roman cornices.

In Germany are generally found beneath the roof cornice small corbels connected by arches of many forms, that were derived from Romanesque arched friezes, but receded to a purely ornamental form in the last period.

Construction of stnone gutters.

Stone gutters may be injurious to the walls on which they lie, if the butt joints open or by filtration through the stone of a porous nature. To prevent the first damage, the joints may be cast with cement and at each side cut with a sinking about 1/2 cm deep and 2 1/2 to 4 cm wide in the bottom and sides of the gutter (a in Fig. 865), which is then coated with cement applied on the freshly cut surface, so that this forms a mass with that filling the joint. This is at least a means alone invented by the mason, as practice has taught us. (Note). For geeater security may be cut under the joint in the top of the stone beneath the gutter a grrove ending at the front.

Note. The same means is given by Viollet-le-Duc.

Compbete safety from filtration through the stone itself is afforded by careful selection or by placing the channle before the face of the wall and therefore resting on corbels. It may further be sought by a coating of the bottom of the gutter, for which modern chemistry affords many means though not yet tested, and there is generally preferred a lining of lead. This lining that has frequently come into use in restorations in modern times, may easily become very injurious, if the fastening to t the stone is fully secured, which can only occur where the lead sheets must lie on the stone, and must pass beneath the undercut projection of the balustrade.

The water is removed from the gutters by spouts or gargoyles, or by leaders according to the new system.

Spouts.

These either lie at the height of the gutter, so that their channles merely form a bend from the latter (Figs. 866, 866 c), or they belong to a course beneath that (Fig. 867).

In the first case the spout has the form shown in section in Fig. 866 a. On account of the weakening that the stone must suffer at a by cutting off the border, the mass of it must be redu-

reduced as much as possible at the front, and this is generally done by tapering in all directions, only the lower surface remaining horixontal, as seen by Figs. 8.6 to 866 c. Slope is made by sinking the bottom and the velocity of the flowing water is increased by narrowing the channel resulting from the diminution of the stone. This latter is of special importance, for water dropping too slowly is easily driven by the wind from the vertical back against the wall. The width of the mouth on some later spouts perfectly corresponding to their purpose is 1/3 the width at the junction with the gutter, while in those made not long before and diminished less, this difficulty made itself felt. Likewise the projection of the spout is of particular importance and is generally to be made as great as the stone and other things permit. Special care is to be taken in this if the spout lies above a buttress, and it must then project as far as possible beyond the outside face of the buttress. Thus an undercut before the mouth of the spout (see u) is useful to prevent the water from following back the under surface.

If the outlets lie beneath the gutter, an arrangement offering many advantages, either the raised edge of the channle must be cut away for the width of the outlet channel or the bottom must be perforated. The first arrangement is simpler (Fig. 867) and less exposed to stoppage and can be improved by returning the moulding so far that the exit of the water sidewise is avoided. (Fig. 867 a). In the latter case an undercutting of the sides of the opening is preferable, at least in the direction of the flow of the water.

A reduction of the free length is usually made by the insertion of a corbel beneath, Fig. 869 from the church of S. Maria at Marburg.

The spouts may be arranged in various ways over the buttresses, either independently over their caps, or supported by buttresses. More on this will be seen later. More seldom do they lie between each two buttresses over the middle of a bay, as on the north side of the church of S. Maria at Marburg.

The external form of the spout generally shows only a chamfer bordering the lower angles, likewise diminishing to the front, but returning to the corncie or face of the wall as a rectangle. (Fig. 866 b). On the choir of the foundation church at Treysa

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on the contrary are found undiminished spouts on whose lower edges the moulding is broken around and shows the profile beside the mouth (Fig. 868).

Gargoyle.

The richest and most ornamental form of spout is the adoption of forms of animals, with an open channel on the back and neck, that is only closed by the head above like a skull (a in Fig. 870 The diversity of these so-called gargoyles is sufficientcy known. Starting from strongly conventionalized forms, they ever assume more animated poses, that finally make their function entirely recognizable. The treatment becomes more naturalistic, they partly represent actual animals, but chiefly infernal monsters, sometimes assume human forms, and also sometimes bring out very droll scenes, like that gargoyle in S. Blasien in Mühlhausen in the shape of a cask, whose cock is turned by a little human figure, and usually afford the best place for expressing all raillery. Aside from such humorous representations, many advantages are peculiar to the earlier mode of treatment. That consists of quiet lines better suited to the whole, to their secure location, to their treatment less exposed to injury and their clear expression, to which their function belongs.

In the earlier period the entire figure is seldom expressed, as a rule the rear part being growing out of the cornice (Figs. 864, 870 b, 870 c), or it is shaped like a corbel to support t the body (Fig. 870 b), but always the pose is vigorous, the line of movelenm and especially the neck is beautifully curved (Fig. 864), while in the later time the entirely free beasts with only the rear part combined with the cornice, thus developed in their entire figure with free cut legs and fanciful turns of the heads produce a certain disquieting effect, and the general increase of the amphibious character itself becomes repulsive.

The entire arrangement for the removal of water has an undesirable similarity to the form of the Greek syma. Likewise the water is stored behind the latter and is ejected through the lions' masks with spouts, just as in Gothic architecture by the gargoyle. Only all projection of the lion's mask is avoided, a and the mouth is only thrown beyond the base of the building by the entire projection of the drip slab, since it is treated at the same time to afford that a direct protection from rain.

But the conditions of the possibility of such an arrangement

lies in the predominant relation of the dimensions of the columns and architrave to the height, in the nature of the material and the cilmatic conditions. None of these requirements were g given in Gothic works, the smaller the thickness of the walls did not permit a wide projection of the stone cornice, while t the predominant proportion of the height of the acute angle of fall of rain would have required a proportion far exceeding the Grecian. To protect the lower parts would have required above widely projecting parts that must be more exposed to storms. Therefore that projection is here found only retained for the spouts, even increased in the endeavor to avoid the covering of the face of the wall by the cornice.

Leaders.

In modern times instead of spouts is usually assumed the conduct of the water in vertical leaders of iron or zinc, since in the larger cities this is even required by the police. Yet it has only been successful in very rare examples, to give these attachments a suitable and thus a reasonable form.

On the one hand the unsuitable material in which they are executed is blamed, and yet this in greater part belongs to the custom to allow certain ones to masquerade as not foreseen in the different patterns and standards, or to separate them from the entirety and regard them as necessary evils, where it is better, the less one has to do with them. Hence leaders are usually seen to represent little columns with capitals, flutes, broken cornices, or by natural inclinations under the main cornices and around the different bands with the strangest bends and breaks, which then become leaky, and then assume a brownish yellow coating consisting of dust and rust, interrupting the g gloss of the oil paint. Also the mode of fastening is usually very imperfect, often effected by wooden plugs driven into the joints, into which the points of the separate parts with rings or clips are driven, and also any removal necessary for a stoppage or injury is made difficult in a high degree.

In Viollet-le-Duc is found the construction of a lead leader, that we must mention here in the lack of an example of our own. According to the required length, the entire pipe consists of a greater or lesser number of pieces, that are stuck into each other so that the upper end od the lower piece is outside and below this projection, set in iron wall holders, so that the

number of the latter is determined by that of the pieces, and the projecting edges of these with the irons form a sort of bands of the entire form. The pipe itself is square in section to allow a certain enlargement in case of stoppage, and the lower mouth is formed by bending forward the back instead of an elbow. Below the gutter a basin fixed in the same manner, which also encloses the upper piece of the pipe, just as the separate pieces are set in each other.

According to this system are the pipes made on the sacristy of the cathedral of Amiens erected in recent times. Their connection with the stone gutter is effected in a drily humorous way, with a projecting beast like a gargoyel dropping the water through an opening in its rear into a basin placed beneath it. It thus actually seems that the basin has a small space between itself and the spout, and the latter is generally indicated, n not only as consisting of a hole in the bottom of the gutter, but further that of breaks by belt mouldings is avoided. This can occur in two ways, either according as the cornice or the gutter ispperforated. In the latter case the continuity of the course of the body must be preserved when the stone basin is o connected with the cornice, into which the pipe over it leads the water and from which it runs into the lower pipe. A greater advantage for any repairs would further result, if the pieces of pipe could be separately removed. For this purpose these must not be fixed within each other inside the bent edge, but sufficient play be left that each separate piece can be raised, and if two are raised, one could be removed.

a. Hall Churches.

If the principles of Gothic construction permit the most varied forms of cross section in the measure, that a rich comparison of the different cross sections of churches forms a most interesting study, there may be distioguished in this endless diversity two systems, that indeed pass into each other by a great number of intermediates.

The first system is based on the fact that the thrusts of the vaults of the nave oppose each other in the piers and entirely or partially neutralize each other, and accordingly comprise t the various arrangements of aisles of equal height, the so-called hall churches, the second system or so-called basilican plan exhibits a raised middle aisle, and opposes the thrusts of the

vaults by a means of resistance produced in a different manner.
Under the designation of hall churches may be comprised all two, three or more aisled churches, whose vaults have exactly or approximately equal heights. Churches with two aisles have already been more nearly described in regard to plan (p. 276 to 282), which did not there explain the peculiarities related on one hand to the cross section of single-aisled and on the other to that of two-aisled churches. Also the cross sections of five-aisled churches (see p. 289 on these) refer in most examples b back to three-aisled, that will alone be mentioned in the followi
Churches with four aisles belong to the oddities, taking as an example the parish church at schwaz in the Tyrol with four-aisled nave covered by a common roof. As another exceptional f form may be mentioned here the five-aisled western portion of the Late Gothic church of S. Barbara at Kuttenberg, whose three middle aisles rise as an ordinary hall church above the outer side aisles.

General conditions of stability of the hall church.

Aisles of equal width.

When the three aisle vaults exhibit equal spans, heights, and further the same forms, there are the same conditions of stability already developed for the plan with two aisles, i.e., the dimensions of the detached pier are chiefly determined by the vertical load and those of the external wall by the thrust of the vaults of the outer aisles, entirely independent of that of the middle aisle. Therefore the outer wall is to be constructed exactly the same as for a single-aisled church with equal thrust of the vaults (p. 235). At most the wider roof may add other requirements by its different construction and the greater wind pressure that in the same case demands somewhat thicker external walls and their buttresses.

If the middle piers receive no roof load, and by sufficient resistance of the outer walls struck by the wind are not notably affected by the wind, then as stated, their dimensions only need to be determined by the quiet vertical loads resting on them (p 278), and these may then become quite slender. On the contrary if the piers are affected by roof load or wind, they must either be correspondingly strengthened, or the vaults or cross arches over them must have in themselves sufficient stiffness to conduct all thrusts to the strong external walls (Figs. 412, 413).

A fine example of a plan with three equal aisles is afforded by the church of S. Maria at Herford (14 th century).

Different widths of aisles.

For different widths of the aisles, assuming a similar kind of vaults, the thrust of the wider, usually the middle aisle, exceeds those of the narrower aisles, and therefore above the pier is only a partial equilibrium of the thrusts, and the surplus must be assumed to be transferred to the side aisle, whereby three possibilities result.

1. The middle piers are so strong, that they alone can receive the surplus, and only the thrust of the side aisles comes to the outer walls.

2. The surplus thrust is partly taken by the middle piers and partly by the outer walls.

3. The middle piers are relieved from this as from all thrust by suitable means. The thrust against the external walls then becomes as great as the thrust of the middle aisle. Therefore in this last case the external walls are to be made correspondingly stronger than in the first two cases.

It was formerly the opinion that the first case always existed, i.e., that the surplus of the middle thrust must be resisted by the pier. The vaults of the side aisles were held to be unable to transfer thrusts. But thereby could not be sufficiently explained the extremely slender middle piers of certain churches and on the other hand the excessive dimensions of the buttresses, and in regard to the latter a certain extravagance was attributed to the old masters.(This view is also found in the earlier editions of this manual. Second edition, p. 455, 456).

But now it was sufficiently shown above (p. 168), that the o cross vault already could stiffen transversely or transfer thrusts by the peculiarity of its form in contrast to thin tunnel vaults. Where this did not suffice, the end was attained by a stiffening of the transverse arches (p. 169).

This property of the vault did not escape the ancients' as in other places, they frequently utilised it in hall churches, where it was employed to reduce the middle piers. This is shown by the form of the vaults in many works and still more by the contrasted ratio of the dimensions of middle piers to the buttress

Accordingly middle piers and buttresses take the places of each other to a certain degree, and one can be made smaller if the

other is correspondingly strengthened. This is shown by the monastery church at Haina, that has only thin outer walls and very strong middle piers, while in many other examples, Friedberg in Hesse, Viener-neustadt, Kuttenberg, etc., the external walls are conversely strong in comparison to the light piers.

To place the dimensions of the middle piers and outer walls in a definite relation to the clear width of the aisles must a appear absurd with the varying conditions of stability, but in the old examples the width of the middle pier varies between t the wide limits of about 1/3 to 1/12 of the middle aisle (as a mean between 1/6 and 1/8), and the external buttress including the thickness of the wall varies from 1/3 to 1/1 of the width of the side aisle (averaging 1/2 to 2/3).

Stability of the middle pier.

As just stated, the dffference between the thrust of the side aisles is either received by the middle pier if made sufficiently strong, or is entirely or partially transferred to the external wall and its buttresses. In most cases it will be treated thus; relieving the middle piers of the thrust as much as possiple, there are three ways possible:- 1, the vaults of the side aisles are made to thrust so strongly by their flat form or great weight as to neutralize the thrust of the middle aisle; 2, the side vault still remains light but is made stiff, i.e., it receives a form making it possible for flatter lines of pressure to be formed in it (in cross vaults lying in the vicinity of the crown or in the cross arch, p. 163 to 169); 3, over the side v vault and separated therefrom is assumed a stiffening of the middle aisle from the external walls. This plan is only possible with tolerably high middle aisles and leads to the buttress system of the basilica. The height of the vaults with regard to e each other plays a great part everywhere in neutralizing the thrust.

The vaults of the side aisles can begin at the same height as the middle vault (Figs. 350, 351), it can be raised or stilted above them (Fig. 352), or it can be placed lower (Fig. 354). These different heights of vaults in any combination with one of the just mentioned transmissions of the thrust produce the different cases of stress in the middle piers. The most important of these were represented earlier in Figs. 350 to 355 (also see the corresponding text, p. 127), and they may be comprised

in the following.

Very thin vaults in side aisles.

a. The vaults in middle and side aisles commence at equal heights. The most unfavorable case occures when the narrow side aisle vaults are carried in slender lancet form to the same height as the wide middle vault (Fig. 350), the difficulty indeed increasing with the difference in width of the vaults. It is to be seen from the sketch in Fig. 350, that the intersection of the vault thrusts does not fall in the middle of the pier, but is unfortunately nearest the side vault. Moreover the resultant of the thrusts is very steeply inclined, so that the pier must have a great width to surely contain it downward. If the side aisle is quite narrow, the pier thus requires nearly the width which it must have if the vault of the middle aisle alone existed

A transfer of the thrust over it to the outer walls is here but imperfectly possible, for a thickening of the side vault w would only be very unsightly, and could only be executed with care that the slender form (Fig. 127 D), by the placing of masses on the otherwise readily executed vault or on its cross arch, and a stiffening of either the crown of the vault or of the cross arch could only reach the upper part of the middle vault, and therefore could not prevent the middle vault from always placing a considerable portion of this thrust at the height of the springing.

Similar proportions of rise in the aisles.

Much more favorable are the side vaults when their proportion to rise is made less, so that they correspond to that of the g great vault ($\frac{f}{b} = \frac{f}{13}$ in Fig. 351). The thrusts for equal thickness of the vaults are then about as the spans. The intersection of the thrusts is less distant from the middle (of the pier) and the resultant is steeper downward. Moreover for a great difference in widths of the aisles the pier must have a considerable width, if it must alone receive the excess of the thrust of the middle aisle.

Construction of the line of support or a calucaltion can be made more simply by taking the thrusts from Table I, p. 135, t that will give data thereon. On p. 154 is given an example of such a calculation. (Read there in line 20 from bottom, 8 m length of bay instead of 9 m, also p. 155, line 21 from top, sq. m instead of sq. cm).

That for such a ratio of rise (Figs. 351, 394) it is easily possible to obtain equilibrium of the thrusts by loading the side vaults or by their stiffness.

On p. 157 is given for the same example, how to make equilibrium possible by building a wall on the cross arch, and to bring the dimensions of the middle pier to a minimum. For this example would be required 8 cu. m. of split stone, which is to serve not for stiffening, but only as a quest load and therefore can be set irregularly. If instead of this stiffening by the cross arch is intended, then a smaller volume would be laid on it, b but which is to be laid in fixed bond, so that the carrying over of a flatter line of support would be possible. Best is an intermediate step, the wall that has special reference to stiffening but on the contrary usually acts rather as a moderate load.

Which of the many possible lines of support actually exists in the wall again depends on the mode of execution, etc. Since with a good wall mass one can count on a certain elasticity or even plasticity, it must be assumed that the force and resistance are to be directly equilibrated as far as possible, In the present case there acts at one side the middle aisle with the force I in Fig. 871. From the other side acts the thrust II of the side vault, but which on account of its lesser magnitude a and lower position cannot equilibrate the force I. The middle of the mass of the wall will be inclined upward to the left, which carries a reaction of the wall on the cross arch in itself, and as a consequence the formation of the line of support III in itself. This line of support is so formed in location and magnitude of force, that it combines with II to produce a resultant line IV, which may exactly equilibrate the force I. So long as the wall on the cross arch is so built, that a free development of such a line of support III is possible, can occur an equilibrium of thrusts over the pier, the latter will receive a vertical or very slightly inclined pressure. If the line of support III corresponding to the requirements in the wall is impossible, then is the mass or form to be changed, which can be done by m means of a graphical or mathematical investigation. If the equilibrium of thrusts is but partially obtained, then must the excess be overcome by the middle pier correspondingly enlarged.

If there also occur over the pier roof or wind loads, then

the vertical [illegible]

not inconvenient but desirable, but the horizontal forces are also to be investigated, how and how far they can be received above, or must be supported by the pier itself.

For every change in the thrusts the line of support III moves up or down, is more or less strongly curved, so that always the equilibrium most possible occurs, and in this way equilibrium is always preserved in variations of the wind.

Vaults stilted at the sides.

b. the vaults of the side aisles are stilted (Fig. 352). Stilting the side vaults was employed in numerous hall chauches of the Early aud later Gothic, and there are mentioned as examples the Early Gothic churches of Hesse at Wetter and Haina, the church of S. Elisabeth at Marburg, the churches at Friedberg and Frankenberg (Fig. 872), as well as the later church at Neustadt near Marburg (Fig. 873), and of the many examples in Westphalian and lower Saxony are taken the cathedral at Minden and the Alexander church at Einbeck, and finally may also the Benedictine church at Oedengurg (beginning of 14 th century), also the church S. George at Wiener-Neustadt, and the Piarists' church at Krems may find mention in Austria-Hungary.

The vaults of the side aisles usually rest on the same capital whth those of the middle aisle, rarely above the latter. The stilting is characterized by a little cornice moulding (Einbeck), sometimes also the capitals of the rounds in the side aisle are lowered to the height of that of the rounds of the middle aisle (Fig. 889), and finally the late examples exhibit a development of the members at different heights without capitals (Fig. 873).

Stilting first has the purpose of elevating the crown of the narrower vault so high that it may rest against the dividing arch at the same height as the middle vault, but it also has besides the structural advantage, that it favors the stability if the middle pier. This particularly appears by a comparison of Figs. 350 and 352. A small stilting of about 1/4 the difference of the two spans already presents an advantage, that the horizontal thrusts occur at the same height (H_1 and H_2 in Fig. 394); it is thereby attained that the total pressure on the top of the pier begins at about its middle. If the stilting be higher as shown in Fig. 352, the intersection of the inclined thrusts of the vaults at the side of the middle aisle, the pressure in the pier that always passes obliquely downward can therefore at bot-

bottom not so easily pass to the outside edge next the side aisle. It follows from this that with the stilting in Fig. 352 the pier can be made considerably narrower than with the lancet arch of Fig. 350. The stilting will not be carried too high, since otherwise the pressure on the pier at top would be found too close to the inner edge, which might at the height of the springing in the middle aisle produce crushing of the stone or a buckling of the pier toward the side aisle, as in fact is observed in the church at Neustadt. (Fig. 873). In such cases it man be an advantage to corbel out a strengthening round above inthe middle aisle.

With the aid of a proper stilting may thus be obtained a favorable transfer of the pressure and consequently a certain reduction of the mass of the pier, but the pier must always remain sufficiently large to receive in itself in great part the difference of the thrusts in the vaults. A transfer to the external wall above the stilted vault is just as difficult as over a lancet vault (see above). It is necessary to effect such a transfer, since men desire to make the middle pier still smaller, or since roof or wind loads are to be received, the end is best reached if the vaults begin at the same height (Figs. 351, 353, 374), or even if the side vaults are lowered (Figs. 354, 355).

By graphical or calculated finding of the line of pressure in the pier, it is recognized that the thrust of the stilted vault (including all extra walling etc.) must always remain smaller than the total thrust of the middle vault, and it must at most increase so much that the horizontal thrusts are inversely as their heights above the base, thus in Fig. 873: $H_1 : H_2 = h_2 : h_1$

Lower side vaults.

c. The vaults of the side aisles commence lower than the middle. Already with beginnings of both vaults at equal heights it may occur, that a difference in the height of the dividing archmakes itself felt, as in S. Laurentius at Ahrweiler, Fig. 890. This will be greater if the side vaults commence lower (Fig. 888). The height between the crowns of the two vaults is closed by a dividing wall, that is borne by the dividing arch, and must be so strong as to be able to receive safely all thrusts produced by the vaults, roof or wind without overturning or bulging (p. 130). If it be not sufficiently resistant by its own thickness, it must be stiffened to a greater or lesser height, whether be-

below or above the roof surface.

If the upper side wall is sufficiently safe, then is concerned the stability of the pier,. The most unfavorable case occurs w when the narrow lower aisle is covered by a light and not stiffened vault, for example a continuous tunnel vault, and this w will so little oppose the great and higher located thrust od t the middle aisle, that the pier requires those great dimensions, which are actually shown in such Romanesque works. If the pier is made too small, then the side tunnel is raised at the crown and broken, whereupon the pier itself is overthrown. By a rampant half tunnel vault men sought to obtain the stiffening applied higher and more effective, but first found the solution when cross vaults were employed over the side aisles. Cross vaults made it possible to form an important transverse stiffening in the flat upper parts (Figs. 412 and p. 168), thereby entirely or partially equilibrating the greater thrust of the middle aisle, thus so greatly relieving the middle pier from this thrust, that it could be made considerably thinner. Cross arches with flat crowns are better suited for this stiffening than swelled or even melon-shaped vaults. The thrust so transferred by the upper parts of the side vault strikes the upper part of the external wall and by the stability of that, etc., can be accepted as sufficiently secure (p. 340).

If one does not wish to trust entirely to the stiffness of the vault, there remains a loading or stiffening wall on the cross arch (Figs. 343, 344).

The loading of the cross arch can be carried very far, since it is favorable to the stability of the pier, that the thrust of the lower lying side aisle is greater than that of the higher middle aisle, the lower the side vault is placed, the greater is to be made its thrust. In many cases it is well permissible to place a solid transverse wall on the cross arch, that extends to the crown or beyond it, and it can terminate horizontally or rise obliquely toward the middle aisle. If it be too heavy, it is to be opened (Figs. 388, 355).

The course of the pressure is about the same as given in Fig. 401 for a simple basilica. If the total thrust of the side aisle exactly equaled that of the middle aisle, the pressure in the pier between I and II would be vertical; if the side thrust is least, the pressure would tend toward the outside, if it were

greatest, as in the drawing, the pressure would tend to the inside. The last leads to a more central location of the pressure below in the pier and therefore is usually most favorable. The wall on the cross arch will prove too great, if even with the assumption of a steep pressure curve in it (II in Fig. 871), th pressure in the pier drops too much toward the middle aisle. As an approximate check may it be assumed, that the magnitude of the thrust should be inversely as its height above the base. T This rule is about right if the loads are all placed as nearly central as possible over the pier, by a projection of the loads to the right or left the stability is substantially affected, indeed favorably if the masses are adapted to the course of the pressure as nearly as possible.

In variations of the pressure of wind, etc., (further see later), equilibrium must always be still possible for the limit cases, and this is still to be regarded as existing, if any needed flatter or steeper line of pressure freely makes possible equilibrium of forces above the pier, that the latter is not drawn inaccurately in sympathy; just for these cases do not approve too heavy or stiff walls over cross arches or flying buttresses for greater heights.

Stability of external walls; effect of roof load and wind.

The stability of the wall with its buttresses must first suffice for all effects of the thrust of vaults,and then also with the contemporary occurrence of roof load and wind,first let the thrust of the vault be considered.

Stability against pressure of vaults.

It has already been shown how the dimensions of middle piers and of external walls may take the places of each other. If the middle pier is so large that it can itself receive the difference of the thrusts of the vaults, only the thrust of the side aisle falls on the outer wall; if the middle pier only takes a part of the difference of the thrusts, the remainder passes to the external wall, whose thrust is between that of the side aisle and that of the middle aisle. On the contrary if the middle pier is kept entirely free from thrusts, then with correct construction the wall must expect a thrust that about corresponds to that of the middle aisle, and indeed with stilted side vaults will generally be somewhat less (p. 372), while with side aisles

placed low it may exceed the thrust of the middle aisle (p. 373, above).

Farther above for the hall churches represented in Figs. 394, 395, were calculations made for the middle pier for two different cases of the middle aisle, that according to the assumption there had to support no roof load, but only dividing arches and vaults. In the first case (Example I, p. 154) the pier was just strong enough to bear the difference between the two vault thrusts, and therefore the external wall had to take into account only the thrust of the side aisle. In the second case (Example II, p. 157), where the treatment was to reduce the middle pier to a minimum size, the external wall received a thrust (H_2 + H_3 = 2160 + 1186 = 3346), which almost exactly corresponded to the thrust of the middle aisle (H_1 = 3240). For this thrust was the outer wall to be calculated like the external wall for a single-aisled church (Example on p. 336).

Effect of roof construction.

In regard to the roof load and also the wind pressure, that is intimately connected therewith, the support of the roof beams is of great importance. Clearest are the conditions when the roof framework rests only on the outer walls, while the pier a and dividing arches are entirely free. One cannot then state as entirely determined how the horizontal wind pressure is divided between the two supports, but however the general idea is much clearer than if a greater number of supports existed.

If the roof rests at the same time on the outer walls and the middle piers, the most unfavorable case would exist, and besides no stiffening connection between the piers or their dividing arches exists there and the external walls. It then depends entirely on the nature of the roof construction and the direction of the resulting stresses how the forces are divided among the separate points.

It may be added, that in such cases a bad truss already of itself exerts a thrust aside from the effect of the wind, and by its great height may act very unfavorable on a support, whether a wall or a pier; it is not at all improbable that this same s support may also have to receive the greatest part of the wind pressure on the roof (greatest on hall churches). If it be the external wall, then if insufficient in thickness cracks and bulges soon appear, which are particularly enlarged by great storms;

if it be an insufficient pier, then will it be crushed and the vaults be placed in cross stresses, so far as this is possible, transferring a part of the excess load to the nearest supports, that on their part must be sufficiently stiff. It is then of g great use, if at least strong walls exist on the dividing arches, that these can carry the side forces to the crowns of the vaults, which they will transfer farther as well as possible. Moderate side forces can thus be very well passed through the crowns of the vaults, but very great wind forces require there a constant and important composition of the stresses, which may lead to injurious loosening of the joints in those parts of the wall and vaults. It is best again to resort here to stiffening cross arches, as we shall see.

Stiffening by roof trusses.

Roof framework on lower beams extended across are mostly usable over aisles of equal height (Fig. 876), and almost completely prevent those injurious effects. They receive the thrust of the roof timbers and make it impossible for the wind pressure on t the roof to be transferred to single supports. The entire effect of the wind is carried to the beams, and seeks as a whole to t thrust in their direction. On their part the beams tend to press on all supports beneath them, and indeed the weaker supports t thus receive less thrust, since they are quicker to yield (Fig. 838 a), and on the other hand the stronger supports will later oppose it and consequently receive the greater part of it. But that is extremely favorable; hence one can count on through beams that the wind pressure against the roof will be distributed among the supports (piers and walls) about in proportion to their resistance. The wind against the roof cannot injure the structure, if the stability of the supports in general has sufficient safety.

On account of clearness, only the wind against the roof is m mentioned and not the wind pressure on the outer wall, but the last produces an overturning moment (pressure × middle height of exposure), which must also be safely received. This wind pressure to which is opposed the thrust of the vaults can be mostly taken by the wall affected; where this is impossible, a part must be carried to the nearest middle pier or even across all three aisles to the opposite outer wall, which is to be done through the crowns of the vaults or stiff cross arches, or less

well also through the roof beams.

Stiffening b: the cross arches.

A stiffening wall on the cross arches is the most reliable and monumental means for making possible any transfer of thrust, a and it is especially in place where through roof beams are wanting; it was very frequently employed by the ancients. The wind need only be opposed by the adjacent middle piers, and a wall on the side cross arches suffices; on the other hand if a greater opposition of the thrust over the entire width be possible, the middle cross arches are to be stiffened also. On the latter the walls are to be made as light as possible, not to increase the thrust of the middle aisle unnecessarily, and thay may therefore rise obliquely toward the crown (Fig. 87, a) or be perforated (Figs. 875 b, 413). The thickness of this upper wall is sufficient if 1/15 to 1/30 of the span, and for brick it is seldom necessary to go beyond 1 or 1 1/2 bricks.

Such a stiffening wall can receive in itself the different lines of pressure and will be more effective than through beams, since the side forces are distributed to the supports in proportion to their resistance. Particularly with a correct arrangement of the masses employed, the middle piers can be entirely freed from side thrusts, so that they onlyneed to bear the vertical loads by the aid of their resistance to compression and bending, and therefore also with equal widths of aisles can be made quite slender. Indeed they could be replaced by iron columnswith pivot joints at top and bottom (Fig. 875), or what is about the same, by slender granite posts so arranged by their ends, that no pressure can occur at the angles.

Investigation of the wind stresses may be graphical, whether the piers be only compressed or thrust, but more simply by calculation. By the last column of the Table on p. 103 is found t the magnitude of the wind thrust acting on the roof at all supports, and this multiplied by the height above the ground is t thus the overturning moment to be resisted. This is the moment exerted on the wall by the wind pressure. Now is to be calculated what overturning moment can be resisted by each separate support (pier or wall). For this purpose is calculated the position of the pressure at the ground with any thrust of vaults and the vertical loads (p. 155, 336), and it is now to be seen how far the pressure in the direction of the wind can still move

without coming too near the outer edge. This distance multiplied by the entire vertical load resting on the ground gives the overturning moment which the support can yet receive. The sum of these moments received by the separate supports must exceed the actually acting overturning moment.

Examples of calculation.

Example I. For the hall church represented in Fig. 394, whose piers are sufficiently stoong according to the evidence of the calculations on p. 155 to receive the excess of the thrust of the vaults, the stability of the external walls is to be investigated, with and without wind pressure.

The plain external wall is 20 m high and 1.7 m thick with a window of 30 sq. m area in each bay and is built of coursed split sandstone,weighing 2300 per cu. m.; a bay of the wall accordingly has (20 × 6 - 30) × 1.7 = 153 cu m. volume and weighs 153 × 2300 = 351,900 kil or in round numbers Q = 352,000 kil.

The thrusts of the vaults (without stiffening of the cross arches) are given on p. 154, and it is for the external wall as a vertical force V_2 = 6840 or in round numbers = 7000 kil, but w with regard to the possible transmission of force from the middle aisle here, as a thrust H_2 = 2160 kil, this will be increased to 250^0 kil; it is located 13.2 m above the ground.

The roof with an inclination of 55° has a slope 20 m long, thus above each bay an area of 2 × 20 × 6 = 240 sq. m (p. 162), hence altogether = 240 × 90 = 21,600 kil.

The wind against the wall at 12_0 kil per sq. m has a horizontal force of 20 × 6 × 120 = 141400 kil, with a mean height of application of 10 m. According to p. 163, the wind against the roof exerts a vertical pressure of 57 kil and a horizontal pressure of 81 kil per sq. m, thus on the entire 120 sq. m of the roof surface 57 × 120 = 6840 kil vertical pressure on all supports together, and 81 × 120 = 9720 kil horizontal wind thrust, that acts on the support 20 m above the ground.

A. Locatio of pressure in the wall without roof load and wind. The location of the pressure in the ground area of the middle pier was already calculated on p. 155, and it lies 20 mm from the middle of the pier toward the outside.

The pressure on the ground area of the external wall is found according to p. 140 (Fig. 371) by establishing the equation of moments for the unknown pressure point distant x m from the insid

$$V_2 \times x + Q(x - \frac{1.7}{2}) = H \times 13.2$$

Or 700 x + 352000(x - 0.85) = 2500 = 13.2. Thus x = 0.93 m.

The pressure therefore strikes the ground area at a distance of 93 cm from the inner side or 77 cm from the outer side, and thus is only moved 8 cm from the middle toward the outside. The maximum pressure at the outer edge is found approximately by the Table on p. 145, more accurately by formula 5 on p. 143, and is calculated by this at:--

$$p_1 = \frac{352000 + 7000}{600 \times 170} + \frac{(352000 + 7000) \times 8 \times 85}{1/12 \times 600 \times 170 \times 170} = 4.5 \text{ kil per sq.cm.}$$

Therefore the pressure usually falls at a very favorable place and produces only a moderate edge pressure and remains very small even if with regard to the window opening the entire length of 600 cm of wall is not considered as supporting. The addition of the weight of the roof without wind scarcely changes the result.

B. Location of the pressure with full effect of wind (120 kil per sq. m). The wind against the wall produces an overturning moment of 14,400 × 10, which must be opposed by a moment of stability of y × (352000 + 7000), from which is calculated, y × 359000 = 14400, and thus y = 0.40 m.

I.e., the pressure falls about 40 cm farther in the direction of the wind, so that instead of being 93 cm from the inner side it is now only 53 cm from it. Then the maximum pressure at the inner angle is, according to formula 6 on p. 144, since it lies outside the kern of the section:--

$$d_1 = \frac{2(352000 + 7000)}{3 \times 600 \times 53} = 7.5 \text{ kil per sq. cm.}$$

Therefore the wall can very well resist the wind acting on it, and it can even receive a part of the wind thrust on the roof.

The wind against the roof produces the great overturning moment of 972 × 20 = 194,400. This can be assumed to be neutralized by the external walls and the middle pier at the windward side, since these wind and vault thrusts oppose each other. For the middle pier that with a moderate addition for the roof load weighs 75,000 kil, the removal of the pressure may be taken at about 35 cm, and then 75,000 × 0.35 = 26,250 and be taken ar the overturning moment, since its remainded of 168,150 m-kilis is to be borne by the external walls. If to the weight of each wall is added an average but concise addition for the roof load of 5000 kil, the total load is:-- 352000 + 7000 + 5000 = 364000 kil. The moment of stability to be exerted by the walls must equal the overturning moment:-- [illegible]

thus $364000 \times y_1 + 364000 \times y_2 = 168,150$. Hence results $y_1 + y_2 = 0.46$ m.

Hence in both walls the pressure must be moved about 46 cm in the direction of the wind; if 11 be reckoned for the wall affected and 35 for the other, then in both the pressure acts equally near the edge, namely at (77 - 35) or 53 - 11) = 42 cm. The edge pressure will then be according to formula 6 on p. 144:--

$$d_1 = \frac{2 \times 364000}{3 \times 600 \times 42} = 9.6 \text{ kil per sq. cm.}$$

This stress seems not too great for good coursed brick masonry it it is remembered, that such an effect of the wind is extremely rare, perhaps never occurring during the existence of the b building. (Note). The small removal of the pressure from the k kern is also inconceivable in these circumstances. Likewise a less uniform distribution of the thrust to the walls would not make much difference.

Note. The static proof required by the police officials for the construction of buildings, heretofore usually neglected the effect of wind on masonry, which is however an excentric direction of the pressure, and it would be proper to extend the limits of permissible stress, where these moments are accurately considered. Perhaps it might be advisable to set two limits, one for permanent loads, the other for those seldom occurring and perhaps for stresses only after complete hardening of the mortar.

Example II. For the same hall church are employed very ulender middle piers and walls placed on the cross arches.

The calculation that will not find further space here quite corresponds to the former, except that the thrust of the wind against the external wall is greater, and the wind is alone to be received by the outer walls without the aid of the middle pier. The thickness of the wall previously assumed also shows itself as sufficient for this case. If the roof framework rests on 4 points (piers and walls), only two of which as the walls must receive the wind thrust, then a slight anchoring to the l latter may be proper, especially for very steep roofs.

For simplicity a plain external wall is assumed in these examples; if the wall has offsets and buttresses, the investigation would be the same on the whole, as shown by a glance at the corresponding calculations for a single-aisled church (p. 337).

Roof of hall church.

As the design of the vaults is decisive for the interior, so

is that of the roof for the e?terion of the hall church. But b both designs are related to each other and exert a certain reciprocal action on each other.

If we assume at least an approximately equal height of the different crowns of the vaults, then would the design of the church at Immenhausen represented in Fig. 8/6 be nearest, that exhibits a roof with continuous truss beam extending over the three aisles, There the intermediate rafters stand as hammer beams and they form with the walls placed on the dividing arches a further support of the framework of the roof. Here the difficulty in finding timbers of sufficient length for the truss beams may lead to placing them only over the middle aisle, and the beams necessary ofer the side aisles resting on leveled dividing arches and on the sills anchored by the middle beams. T This connection can be made in different ways, and also the arrangement of a common roof over three aisles of unequal height of crown. Then the through beams over the side aisles either take an inclined direction as in the left half of Fig. 877, or like the construction found in the right half of Fig. 877, or where are the beam a, post b, sill c and again the beam d, the wall plates being anchored by these. Accordingly the top of the wall of the side aisle lies lower than the crown of the vault of the middle aisle, and this extends into the roof.

If the design of a common roof over the three aisles is simplest and affords certain advantages in the removal of water, t then for the external effect it is most unfavorable and corresponds least to the proper character of the cross section. This lack of expression already appears in the concealment of the design in three aisles, and even more the junction of the roofs of the choir and that of the nave only to be obtained by powerful ways or by certain expedients. This junction would first require an attic of the nave terminating at the east with a closing bagle wall, either having the choir roof at the same height as in Fig. 878, or joining it with the same inclination. In both cases would be necessary either a strengthening of the triumphal arch to receive the wall triangle a b c or the corresponding lozenge surfaces, or the arrangement of a pointed arch turned beneath the roof of the church in Fig. 876. To avoid the latter is then found separately only the triangle a b d through a wall, so that the masonry and wooden wall lie under the edge of the

gable. Then further sometimes the wall triangle a b d is removed and the entire triangle d a c is closed by a wooden wall. But it is more correct to form the eastern ending of the nave roof by a hip roof, into which the choir roof intersects (Fig. 879). The last design is almost requiref by high side choirs carried high. If there remains a reentrant angle a c b , let the latter and the high choir, as in Fig. 880 on which rests the straight through eaves of the roof (Fig. 881). With equal longitudinal extension of all choirs is then given the means most usable on the brick churches of Baltic countries, for further simplification of the roof, and even for the design of an eastern gable corresponding to the entire width of the nave.

Likewise the junction of the roof of the single-aisled transept to that of the three-aisled nave leads to the most varied designs, according as the height or inclination of both roofs is the same. In the first case the roof of the nave extends to the western, and the roof of the choir to the eastern roof of the transverse aisle (Fig. 882). In the second the eastern roof of the cross aisle may extend in a hip of the roof of the nave or the latter can intersect the roof of the transverse aisle a and be connected with the choir roof in one of the ways mentioned above (Fig. 883). An arrangement certainly bearing the character of a makeshift is found on the choir at Wetter (Fig. 884), where the roofs of the nave and choir have equal heights and have the same inclination as the roof of the transverse aisle, so that the oblique surfaces a b c d join opposite the latter. (This arrangement results from a later alteration).

The magnitude of the roof surfaces makes their ornamental treatment appear desirable, that can be made either by the number and form of the openings, or if the material permits, by patterns in several colors. For this design are suited all materials used for covering the roof, so far as the conditions permit them to be obtained in different colors, but especially glazed tiles. Very rich examples of this kind are found on S. Stephen in Viennaand on various churches of Burgundy, of which we give in Fig. 887 an example from S. Benigne in Dijon after a hasty sketch, for whose primitiveness we cannot answer indeed. (There are indicated white, yellow and light gray, red and dark gray, green and grayish black, and black). Least adapted to such treatment are the different metal coverings. Yet very rich effects are

produced by partial gilding, by the location of certain plates, by the form of the openings and by the design of the existing crowning of the ridge.

Longitudinal roof over each aisle.

But the arrangement of the common roof suffers in the main d defects, that it is only connected with the form of the whole and does not result from that. Yet the latter condition decidedly occurs in the covering of the didderent aisles by three parallel and longitudinal roofs (Fig. 885), between which lie gutters from which the water either flows lengthwise at west and east through spouts, or is led to both sides by special channels beneath the roofs of the side aisles, a plan which of these expedients relating to the junction of the roofs of the choir and transepts make indispensable.

Transverse roofs over side aisles.

Those covered channels beneath the roofs of the side aisles are then changed into open ones by the arrangement of separate transverse roofs over the separate bays of the side aisles with gutters over the cross arches separating the latter, which either extend as hip roofs to the roof of the middle aisle or may intersect it (Fig. 886). Particular care is to be taken always in the construction of the gutters. They must be as wide as possible, accessible from the roof of the middle aisle, be made of heavy lead and extend at least 6 to 8 inches under the covering of the roof; but in the upper wall connected therewith lies the only defect in the entire design, which in other respects is to be termed the most complete, as it is found on the best works with aisles of equal height. We mention here the church of S. Elisabeth at Marburg, further the cross church at Breslau, S. Blasien in Mühlhausen and the church at Friedberg. It existed on S. Alexander at Einbeck and was originally intended on the monastery church at Haina anf S. Maria at Mühlhausen, as may be clearly recognized. In the last case only on account of cheapness, it was changed into the plan of the common roof covering all aisles, whose sole advantage consists in its ecomony. However the last also fails, when a sufficient substitute was found for the lead gutters. The outer ends of the transverse roof can be closed by hip roofs or ordinary gables.

Middle aisle of greater height.

Middle aisle continues in an attic.

When the design of the roof just described results from the section of the vaults, then conversely the form of vaults as s shown in cross section in Fig. 888 will lead to the adoption of quite different heights of vaults in the three aisles. Thus the dividing arches lie at the height of the vaults of the side aisles, but on them are built walls, solid or opening into the attic, carried to the height a that are adjoined by the side arches of the vaults of the middle aisle.

The entire arrangement is preferably executed in limited proportions. In larger dimensions the faulty lighting of the middle aisle is still injurious, although the contrast with the brighter light in the choir has a picturesque effect.

Middle aisle rises above the roof.

The difference in height of the aisles can be reduced by giving the roofs of the side aisles a flatter inclination than that of the middle aisle, thus forming a break at the latter (right half of Fig. 888). Since the unity of the roof is broken, the unequal heights of the aisles, the upper wall of the middle aisle above the junction of the roofs of the side aisles extends up in the form of a frieze separating the two roofs (Fig. 888 a). A further elevation of the middle aisle with this part of the then leads to opening it by windows, and thence to the fully expressed system of the clearstory of the middle aisle, so that the design in Fig. 888 in a certain way occupies a middle position between the hall church and the basilica.

Separation of the middle aisle.

This intermediate position is more decidedly expressed in the structural relations of the vaults and piers. The entire arrangement of the cross section as shown comprises, that a direct opposition of the thrusts does not occur, and therefore a resistance is to be provided against the thrust of the middle aisle, either by strengthening the aisle piers or by any other plan. To this belongs the erection of abutment walls on the separate cross arches dividing the side aisles. The latter then require a stiffening while those walls are carried up beneath the roofs of the side aisles and enter into their construction, i.e., can receive the purlins. The necessary communication of the attics over the separate bays, or the reduction of the masses for static reasons (p. 128) then requires an opening in this abutment wall, whose design is to be such, than at the height of the

point of application of the thrust of the vault of the middle aisle remains a sufficient thickness to prevent the sliding of the separate courses and therefore the bending of the piers, i. e., the total thickness a b + b c in Fig. 888 is sufficiently large, or the opening must be arched in circular form. These w walls can then fulfil a twofold purpose, for then first ensure by their weight the unchangeable line of the cross arch, i.e., prevent any bending of it upward and thereby an overturning of the aisle pier outward, but then conduct the thrust of the vaults of the middle aisle to the buttresses standing in the outer wall, and in a senes form a shoring of the parts of the wall exposed to this thrust. The load on the cross arches must not be too great, since otherwise the piers would be forced inward too strongly. (Further on this on the preceding p. 373).

If follows from this that those walls can furnish under certain conditions the before mentioned utility of a separation of the aisle pier, but that its construction as soon as it becomes too heavy easily becomes faulty, and is better replaced by one that avoids the loading of the cross arches, and that is the use of the buttresses lying under or over the roof, to which we shall return later.

Relation of heights of choir and of middle aisle.

The choir and the middle aisle have the same height as a rule. Variations are indeed often found, partly resulting from the s system lying at the ground of the entire design, partly are changes from the original design as the consequences of an interruption of the construction. Thus a greater height of the nave, according to the arrangement of the system of vaults results f from the plan of two-aisled choir as found in a particularly striking way in the church of Niederaspe near Wetter in upper Hesse. For here the beginning of the arches extends from the m middle row of piers and the cross ribs from the same point rest on the keystone of the triumphal arch, so that the crown of this arch and of the choir vault drop to the height of the basis of the vault of the side aisle.

Likewise in single-aisled churches with narrower choir, the unequal spans of the choir and nave vaults on a common basis lead to a lesser height of the former, as the cross section of the Minorites' church of Duisburg shows.

Conversely is found a greater height of the choir on the churc

in Frankenberg indeed in combination with a widening thereof, but still in such a degree, that it also has a proportion of height exceeding that of the nave.

Meanwhile as stated, equality in heights of choir and middle aisle is the rule.

Galleries of hall churches.

With egaal heights of the aisles there results for the narrower side aisles a far more important proportion in height than for the middle aisle, indeed twice when the ratio of width is 1 : 2. Therefore it is next to divide the height of the side a aisles by intermediate vaults extending between their piers and walls, thus by the arrangement of the so-called galleries to enlarge the interior of the church, obtaining for the separate divisions in height of the side aisles a proportion in height quite or approximately harmonizing with that of the middle aisle.

Stone galleries.

Examples of such vaulted galleries are found to be especially common in the later works of the Rhine provinces, thus in the city churches at Kiderich and S. Goar, in S. Leonard in Frankfort and of S. Laurentius at Ahrweiler. The arrangement of the latter is shown in cross section in Fig. 890. Men originally regarded these galleries as separate aisles and furnished them with side altars, that are still preserved in Kiderich. On the other hand until recent years, there was found in the bay of S. side aisle precedeng the transept of the church at Wetter a gallery built later at the beginning of the 16 th century, which was originally intended to receive the organ and later was utilized as a so-called box for distinguished guilds. The design of this gallery thereby affords special interest, because its vaults are placed very low, cross and diagonla ribs are formed as rather flat segments, so that their mouldings intersect the round piers.

But likewise in many Early Gothic works with high middle aisles in France, on the collegiate church at Mantes, the cathedral of Noyon and that of Paris, are found such galleries on vaults above the side aisles, where the just mentioned separate position is especially accented, in that the width of the arch opening into the middle aisle is divided by little columns connected by arches. The vaults over these galleries in the cathedral of Paris show, that for later purposes, as we shall soon see, a

substantial peculiarity in raising the outer compartment from the keystone to the window wall.

Since the 16 th century have men believed that these galleries must be ever more common, at first in Protestant churches, but later in certain countries at least, also in Catholic churches, and they were devoted to a purpose essentially differing from the original one, when the separation from the other interior of the church and the establishment of separate altars therein was omitted. Then a view of the pulpit and altar in the rear row of seats was usually regarded as a necessity, and this must compel a raising of the floor toward the exterior like an amphitheatre.

It has been assumed as decided, that especially in restricted dimensions the effect of the interior is injured by these additions; if it is further true that the need for room is generally only imaginary, and as the requirement of a free view of the p pulpit only comes from a certain pious vanity; it is no less fixed that in many cases the disproportion betwien the actual need of room and the means at hand compels this cheapest mode of obtaining room, or that at least the omission of the galleries and even only it is not carried out against the opposed wishes and opinions. It is yet more certain that Gothic architecture is more suited than any other to fulfil even an unfavorable programme.

Among the possible forms for the present purpose, one intimately interwoven with the entire mass of the building is most preferable, thus being the gallery inserted between the piers and outer walls. Therefore we attempt in Fig. 881 to carry this out with the least height, when we assume spans for the middle and side aisles of 7 m and 4 m in the clear and all projections, and place the base line of the former at the height of 5.5 m. As a minimum height of the crown of the cross arch of the gallery turned between the piers, we take 3 m and give this a rise of 0.75 m, assuming 4 m as the clear distance between the piers. If we now assume an inclination of 90 cm for the inclination of the floor of the gallery, the diagonal ribs of vaults forming the same receive a rise of 1.5 m, and the side arches at the o outer wall have one of 2.25 m. The entire clear height of 4.5 m thus results beneath at the wall.

With the assumed proportions of the plan, a semicircular form

of the diagonal ribs in the middle aisle require a height of a about 5 m. Accordingly we construct the vaults of the side aisles according to the data given on p. 371, so that the points of application of the thrusts are at the same height and accordingly their basis is about 75 cm above those of the middle aisle vaults. Therefore we place the capitals below the dividing arches and the ribs of the side aisles at the height of this basis, therefore higher than those of the middle aisle, so that as shown at c, they run against the cross ribs of the middle aisle. Thereby they will be raised as high as possible above the heads of persons on the gallery, and indeed in this case they lie about 2.5 m above the floor.

Wooden galleries.

If such galleries must be made of stone, a necessity which certainly may appear in limited proportions by the lack of height and of means, the design of the woodwork must be such that the stonework of the piers will not be weakened by the inserted timbers. Therefore either those parts of the piers into which wooden posts or beams enter must have a changed form corresponding to this relatiin, or no connection of the two parts can occur. The first purpose would be attained by a corbel on the pier, which would afford the necessary bearing for the woodwork, so that the mass of the pier should not be weakened, but in a more perfect manner be stone segmental arches turned between the piers, on which the beams could lie. But contact could be avoided by placing separate posts at both sides of the piers. For the treatment of the woodwork and especially of the posts are given examples in Figs. 606 to 623.

3. Churches with Clearstory over Middle Aisle (Basilica) and their Buttress System.

Buttresses over single side aisles.

In hall churches with unequal heights of aisles (Fig. 333), we have the separation of the points of application of the thrusts and the resulting [illegible] resistance to the higher middle ailes. This necessity increases with the difference in height of the points of application, and therefore most strongly appears with a height of the clearstory walls affording independent lighting of the middle aisle.

Importance of the clearstory of the middle aisle.

But in the adoption of the upper windows consists the particula

material reason for raising the middle aisle, just as in the lack of this lighting is to be found a defect in the plan of a aisles of equal height with great widths. This is plainly felt by the view from the transverse aisle, or diagonally from a bay of the side aisle, where the contrast of the dark shadows if the vaults of the middle aisle with the full light of the vaults of the side aisles produces a bad effect in even the most finished works.

Moreover the impression produced by the whole is clearer; every part has a proper value, so that the development of the elevation in a certain sense is furthered by the arrangement of the design with side and transverse aisles, while that with equal heights of aisles, it is to be designated only as not opposing the latter. It is the proper church in all its internal subdivision that is represented, while the different design with aisles of equal heights approaches more the character of a hall added to the choir.

But the peculiar triumph of the art lies in this, that it succeeded in forming a combination of the traditional basilican t type with the advances in technics, and thus giving a justified value to both principles.

In the flat covering of the basilica was offosed by none of those technical difficulties, that were caused by the vaulting and the need of abutments. If one now thinks that the requirement of vaulting was recognized, the suitable design for this was found, at the same time the prescriptions of tradition were removed, in other words radicalism was called to the execution of the new designs. What would then be nearer than to abandon the old types, to strive henceforth for a counter action of the vaults also for church buildings, therefore directly passing to the system of aisles of equal heigtt, for which use was in the most varied directions found in the Romanesque churches of Westphalia as well as in certain French provinces. But thereby was not merely a phase of the development but the highest stage, w which was even attained by the victory over the opposing difficulti

Instead of these the masters in the 12 th century sought one means after another, and then ended by solving the problem of combining the requirements of the present with the transmitted form, creating a building and surpassed all precedents in depth of constructive thought and in acuteness of expression, founding

a principle whose endless fertility also came to the aid of the different system. For without the material advantages of equal heights, certainly the prevailing system in Germany, recognizing the worth of so many examples thereof everywhere, it must be assumed that by those would not have been invented the richer development of detail forms, as first visible in Early Gothic works of this kind. For example how would men have come to the arrangement of the rounds, of the compound pier, if the organism of the construction had not required the separate different parts performing functions at different heights?

Purpose of the flying buttresses.

We have assumed above the independent lighting of the middle aisle as the impelling reason for the clearstory. But even with such a small height of the clearstory so formed as shown on the Liebfrauen church in Worms, there already appears, as illustrated in cross section in Fig. 891, the necessity of a separate resistance to the vaults of the middle aisle. This resistance can only be formed by a completely sufficient opposing mass, and it is therefore only necessary to establish this mass so as to do no injury to the organism of the whole, as such would arise from an enlargement of the aisle piers, then to conduct the forces to be resisted to this mass. The first requirement would be expressed by enlarging the outside buttresses with regard to the increase occurring in the thrush, the second by flying buttresses turned against them, whilh are therefore first considered as struts.

Ensuring against bulging upward. Walls on them.

Accordingly the flying buttresses must have their crowns attached to the outer wall of the middle aisle at the height of the point of application of the thrust of the vault, but with its foot striking the inside of the buttress above the junction of the vaults of the side aisle. It is further necessary to secure the arch from an upward movement of the separate voussoirs, and this first occurs by the addition of a mass thereto as well as by increasing the radius. Accordingly there results in Fig. 891 only for this small height of the clearstory the possibility of the design shown there, whereby the flying buttresses are turned free in the space below the roof of the side aisle, without either supporting the purlins belonging to the roof construction or any extra wall. Moreover the entire design not appearing

externally has rather the character of an expedient certainly employed with advantage in certain cases than that of a real art form. There the considerable dimensions of the flying buttress 60 cm high and 90 cm wide are only necessary to ensure an unchangeable form of the arch line, but may suffer a considerable reduction, when the top of the arch is made an inclined straight line by masonry. This extra masonry may likewise either remain under the roof or better cut through it and be covered outside it by a slab with drip cut at both sides. By the last design would both the resistance to the thrust of the vault be effective at a greater height than would be the system expressed on the exterior. But to both arrangements corresponds in more complete measure that design, according to which the flying buttresses are turned above instead of beneath the roof, by which at the same time is entirely removed the restriction of the height of the clear story peculiar to the latter.

Counterthrust of the arch.

We have then the flying buttress as merely conducting the thrust to the nearest buttress, hence being in a sense regarded as a neutral body like a wooden shore. But in reality the case is different, so far as by its properties as an arch it exerts an active thrust at the junction with the wall of the middle aisle, by which a part of the thrust of the vault is neutralized. The intensity of this force is dependent on the weight and curvature of the arch as well as its loading, but the direction of the force on the direction of its junction with the wall, hence on the location of its middle point (Figs. 402 to 405). The effect of this force would therefore be the greatest against the thrust of the vault, if the flying buttress were made the heaviest possible and were turned in a flat arch, that joined the wall horizontally or somewhat inclined. If the arch is more curved ((for example as a quadrant) and is less loaded, its thrust is less. Thus one is able within wide limits by weight, curvature, and rise of the arch so to determine its end forces in magnitude and direction, as it favors conditions of stability. (Figs. 408, 409, 410). Thereby the thrust of the arch can be made less or greater than the thrust of the vault.

If flying buttresses are employed that much exceed their duty,

the two walls tend to move toward each other, and consequently to firmly hold the vaults. Cross vaults can bear such an increased transverse stress by the frequently mentioned stiffness of their compartments or cross arches,within fixed limits without injury (p. 168, 339). Thus too heavy buttresses are less unfavorable to the vaults with correct height of attachment, and even by "correctly" stiffened cross arches they may preferably increase the immobility of the entire work, but they have another fault as a consequence. For the equal thrust that the arch above exerts against the wall also occurs at the lower end, wherefore an excessively heavy flying buttress also requires a particularly strong buttress, and this must be obtained by a greater quantity of materials. It follows from this, that as a rule a rather light construction of the arch must be preferable. Therefore it is the first concern to reduce the cross section of the arch as much as the ratio of the strength reacting through the buttress to the transmitted pressure permits. But these pressures could change by variation in wind and loads, as mentioned before (p. 1.0), or in other words there may occur in the flying buttress sometimes flatter and more curved lines of support. To be able to receive these at all times without breaking, the means nearest at hand is a stiffening wall on the arch. But since by this a load increasing with the inclination of the upper edge is laid on the flying buttress, as a rule at least for any considerabele inclination to open that wall by a great circle sometimes beset with cusps (a in Fig. 892).

b. Form of the arch line.

With the quadrant form of the flying buttress its thrust is about horizontal against the clearstory wall, and this the horizontal component of this thrust is directly opposed to an overturning of this wall, so that the vertical component remains in full force,loading the aisle pier and the weaker construction above. But just in relation to the latter is advisable a reduction of the loading, and thus it is preferable to shape the flying buttress so that its thrust strikes the wall in an inclined direction, thus neutralizing a part of this force acting vertically. But this inclined direction results from the adoption of a greater radius for the flying buttress, thus locating the centre in the inner face of the wall, as at c in Fig. 891, or far-

farther inward, and thereby the flying buttress receives a height exceeding that of the quadrant. If this height does not exist in the general proportions of the cross section, then the intersection of the flying buttress into the roof of the side aisle, or lowering it to the springing of the cross arch of the side aisle will be necessary. At the Regensburg cathedral a lesser height of the flying buttress is obtained by striking it f from three centres.

Passages in the clearstory wall below the arch.

Below the attachment of the flying buttress and with a full neutralization of the thrust (Fig. 409), for the clearstory wall or rather for the pier formed by it is only a thickness required by the condition of the reacting strength of the stone opposed to the loading reduced by the flying buttress. Hence results the possibility of replacing the pier mentioned by two supports, b between which is spared the space needed for the passage (b in Fig. 892), thus constructing a passage to make the windows of the clearstory accessible, as already represented in Fig. 857. In works in Burgundy, in the cathedral of Toul (Fig. 850), and Freiberg cathedral (Fig. 892) the passage lies inside and the window wall is placed at the outside face of the wall, the flying buttress either direltory serving this as in Fig. 891, or there is set against one of the lower aisle piers, either a corbelled buttress as in Fig. 895, or finally as in Fig. 892 against a mere projection. But in the interior this arrangement occupies space, that was priviously explained in the galleries of single-aisled churches. Accordingly Fig. 892 shows the arrangement of tunnel vaults in the thickness of the wall, and Fig. 892 a is the plan of this Fig. at the height of this passage, that for a row of windows filling the entire length of the bay would receive a form about corresponding to Fig 855 a.

On the same structural principle is based the design of external passages. There the window wall alternates places with that internal pier a b c d in Fig. 892 a, and thus is set back to the inner face of the wall. According to the width of the window the jambs come to lie against the rounds of the side arch, while the tunnel vaults in the thickness of the wall appear externally as on the cathedral of Rheims (Fig. 894). We note here that overhanging form of cross section of this tunnel vault is

not fanciful, but first develops at the jamb from the proportion of the rounds of the pier in the angle at the transverse aisle to the thickness of the wall (894 a), where alone by the adoption of the splay also extending on the arches and before the o other bays results the possibility of the plan of the pier a.

Isolated columns beneath the flying buttress.

Yet where the thickness which the wall resting on the window arches receives by that tunnel vault exceeds the necessity of the necessary stiffness (p. 338) requires in the upper thickness of the wall required by gutters and galleries as well as the roof beams can easily be obtained by the form of the cornice a and by internal corbellings, since the tunnel vaults or rather the arches connecting the piers outside the window wall disappear, and there remains only the pier itself in the thickness of the flying buttress or of a little greater thickness. The flying buttresses are then turned against these piers and are furnished with passages beneath their junctions, while they terminate above either in the flying buttress, or continuing through these have a separate ending. Viollet-le-Duc, Vol. I, p. 63. But it fulfils the purpose to be satisfied, if the thickness of the outer pier formed at the junction of the flying buttress is retained, i.e., the buttress also above the height required by the passage can also be replaced by an isolated column, whose capital stands beneath the ashlar receiving the front end of t the flying buttress, while its read end is inserted in the wall and finds further support by a wall pier projecting from its face. An example of this kind is shown by the buttress system of the Strasburg minster (Fig. 893). Here a is the ashlar met by the crown of the flying buttress arch and supported by the column b, c is the pilaster, whose width exceeds the thickness of the flying buttress as represented in the plan of Fig. 893 a, so that this excess at both sides of the flying buttress enters below the cornice.

By the steeper direction of the top of the flying buttress, the height is increased at which the resistance of the thrust of the vault becomes sufficiently effective in moderate dimensions, by which however the measure of the loading may be reduced by means of the before mentioned openings. If we now assume a complete perforation of the triangle between the flying buttress arch and the straight portion, as by filling it with tra-

tracery or mullion construction, whose strength suffices ho bear the cut stones of the covering (Fig. 899), then the resistance of the height between arch and coping would be lost, and besides the arch itself the straight top or coping would form a second shoring of the wall, but sufficient security is obtained thereby, since even if a part of the thrust acts between the two secured points in Fig. 899, yet their distance apart is too small for a bulging of the wall to result.

Two flying buttresses ofer each other.

But the safety obtained by the top and sidewise stiffening is in inverse proportion to its inclination, and the resistance is almost entirely lost, if it is steeper than the thrust of the vault. But that doubled stiffening is obtained in a more complete manner, and at the same time the height of the line thereby ensured increases as desired by the arrangement of double flying buttresses over each other. The lower flying buttress reaches the clearstory wall about the thickness of the pier above the height of the capital, and the upper one about 2/3 to 3/4 of t the height of the vault, to the latter entirely falls the task to resist the wind forces applied above, etc. The direction of the top will be less steep and according as a rule the perforations must be omitted.

The junction of the upper flying buttress on greater works, as at the cathedrals of Cologne, Amiens and Beauvais, then occurs in entirely the same manner as that of the lower on the block supported by a column, so that the upper column stands exactly over the lower one. But since the purpose of the passage under the upper flying buttress vanishes, there is sometimes found(as on the cathedral of Chalons, Fig. 898), that isolated column is replaced by an external buttress, to which the column receiving the flying buttress is attached as a round. This upper buttress then rests on the lower block and its front face remains behind that of the lower column. Each external buttress at the same time affords a very useful strengthening against the inward forme of the upper flying buttress, which strikes the wall at a place where the proper thrust of the vault is but indirectly effective. Still greater security against that force pressing inward results from the erection of transverse walls on the cross arches, and made horizontal at top, as at the cathedral of Rheims, which then to avoid the excessive

loading of the spandrel of the arch may be opened by circles in the angles.

Certain works like the cathedral of Bourges even show three flying buttresses over each other, which can then meet more safely any variations in thrusts by their strength and points of application. Yet such a large number of arches are unnecessary, they must also owe their existence only to the circumstance, t that at first the master had ont clearly considered the effect of the forces. Likewise the omission of the second upper arch must have resulted from the observation, that a deep arch with a short base stiffened the upper part of the wall too little, which must appear after the first storms shook the building.

A peculiar form of construction recalling the system of the doubled flying buttress, but based on an entirely different principle, is shown by the flying buttresses of the cathedral of Chartres. Here the lower or rather the actual flying buttresses are covered by a concentric arch forming a drip at each side, on which stand little radiating columns connected by round arches. On the end arches brought to a concentric line with the flying buttress lies a low layer of larger blocks and on the latter is one concentric with the lower and corresponding in thickness as an arch, built above to an inclined straight line with a coping moulded at each side. Thus not including the low covering layer and the arches separating the upper arch, and transferring the entire load to the lower one, there are two flying buttresses, the upper usually for receiving the thrust, while they strengthen the lower, so that the upper arch no longer forms a passive stiffening, as a straight inclined coping course would form in like manner.

This double arch at Chartres has been too little considered in its refinements, and like those copings supported by openings (Figs.897) 899) affords undeniable proofs, that the old masters with great acuteness recognized the importance of upper arches and of the stiff coping over single arches as sometimes acting as stiffening against variations of wind, and in a model developed their construction and architectural expression.

Loading of the top of the arch.

But all loading of the lower arch also prevents the yielding of its ashlars and so ensures its curvature.

Such security by loading is effected in various ways; thus on

the cathedral of Cologne by tracery placed on the back of the flying buttress, on other works by separate mullions and arches supporting the coping and water channle, that will pe mentioned later.

Contrary curve of the coping.

In far simpler manner the permanence of the curve is ensured by the form of the straight coping or rather that of the flat arch with the contrary direction as on S. Benigne at Dijon (Fig 895). Accordingly the two opposed arches ensure each other, and both extend in the same way between the buttresses and the wall of the clearstory. But the effect of the form of the upper curve is unpleasing in this example, that is to be referred to the fact, that the curve bends at the flying buttress in a steeper direction.

The arrangement of flying buttresses over doubled side aisles.

Arches of single and double spans.

We have already stated on p. 289, that these may occur by two different principles, according as either the flying buttresses extend as one over both aisles with a radius exceeding their width, as on the cathedral of Paris and the minster at Ulm, or are turned in the ordinary way in two spans. In the latter case are placed piers over those separating the aisles, which pass through the roofs of the side aisles and are joined by the lower flying buttresses, and also the upper rest on them. The lower flying buttresses must then transfer to the external buttresses the thrust led to the intermediate piers by the upper ones, so that the intermediate pier requires no great dimensions, certainly under the effect of a loading acting vertically.

Junction with intermediate pier.

The simplest relation of both arches to each other will then be, that they are entirely equal, or receive corresponding forms with unequal width of side aisles, and that the backs of the l lower continue the direction of the upper arches. Then accordingly as shown in Fig. 896 the thrust of the latter strikes at about a the line leaving the intermediate pier, it is opposed here not by the thrust of the lower arch, but by the wall on it and conducts to to the external buttress. But the thrust of the lower arch strikes the intermediate pier at b and also is opposed by no direct force. If this on account of the small intensity

of the force acting at B from that striking at a above, and further on account of the small distance between the points of application in actural danger results therefrom, then is still t the arrangement given in Fig. 896 a the more consistent, when as on the choir of S. Ouen in Rouen, the junction of the lower flying buttress with the intermediate pier is placed somewhat higher, so that its thrust directly opposes that of the upper, and accordingly the continuity of the direction of the backs d disappears.

Double arches over double side aisles.

If the design of doubled flying buttresses over each other came from the desire to stiffen the entire top of the wall exposed to the different thrusts by securing its ends, the same principle may also find application in the converse sense, in the way that the thrust brought to the intermediate pier by two upper shores is opposed by only a lower one. A simple example of this sort is the buttress system of S. Peter Jr. in Strasburg. (Fig. 897). For here on the back of teal flying buttresses are set posts, that bear ashlars set in an inclined line. These last a also become a second shore just like the preceding wooden strut, so that the thrust of the vault of the middle aisle is led to the intermediate pier at two points over each other, and only the single lower flying buttress opposes by its entire mass those double points of application, and strikes between them, leading to the external buttress. More decidedly is expressed this view if two upper flying buttresses are opposed to a lower one. Such an arrangement is found in the original buttress system of Notre Dame in Paris, where the lower flying buttress of the second span opposes the thrust of the gallery vault and of that concealed beneath the roof of the latter and the flying buttress supporting it, and acting at different heights of the same intermediate pier.

Double stresses from flying buttresses are found on the choir aisles of certain French cathedrals, required by the plan of the pier separating the chapels, so that the outer flying buttress receives much less stress and therefore its active effect nearly vanishes. Hence at Amiens this stress is entirely neglected and the last flying buttresses are conceived as only conductors of the thrust to the outer pier, therefore being replaced by a complete pointed arch.

Arrangement of removal of water by buttress system.

Channels of gargoyles.

The earliest arrangement of channels and spouts undertaken s still in the 13 th century on the cathedral of Rheims, differs nowise from that already explained. By the latter the water coming from the roof of the middle aisle was thrown from the channel into the air, where it was scattered by the least wind and thus falls on the roof of the side aisle without causing too much injury in its scattered condition. If the spouts are now found directly over the flying buttresses, the origin of this may rather be found in a formal need than in the intention to utilize the backs of the flying buttresses to break up the stream of water, which could not be done with the least wind.

But there is in this a not too distant contradiction, that the water flowing down from one roof is first collected in channels, this is scattered in the air and falls on a second roof, at whose base is repeated the collection. Then there is either a step back or one forward to be taken, i.e., either to omit the collection of the water in the gutter of the roof of the middle aisle, or to remove the water collected theron in separate channels to spouts and removing it entirely from the building. The first arrangement is that usual on Romanesque works, and which still frequently occurs in the Gothic period, on Notre Dame at Dijon among others. There are indeed also lacking t the lower channels, yet their addition would be an improvement very well combined with the free flow from the upper roof, and would be thereby justified, that the water from the lower roof falls on the horizontal surface of the roof, and therefore would be more easily carried to the walls, even if not thrown to a g greater distance from them, as by the gargoyles.

Channels on the backs of the arches.

As for the second arrangement, the backs of the flying buttresses are very well suited for the arrangement of the special channel, and there is first concerned the carrying of the cross section of the latter from the outline of the gable into that of the gutter, and then the channel thus formed to reach the stream from the gutter of the roof of the middle aisle. Satisfying the last condition will be more difficult as the distance from the junction of the flying buttress to the roof gutter increases, as it particularly occurs with single flying buttresses

where the necessity of a vertical pipe is found.

On Strasburg minster, as Figs. 893 to 893 b show, wall piers project from the clearstory walls of the middle aisle, that are joined by the flying buttresses, and which above this junction are strengthened by little columns standing on the backs of the flying buttresses. Then the capitals of the latter, as shown by Fig. 893, are taken from the height of the roof balustrade and bear the finials rising above the latter. Within the projections thus formed is found to be cut a vertical pipe, as shown by the plan in Fig. 893 b, through which the water from the roof gutter is led to the gargoyle, which casts it into the channel formed on the back of the flying buttress. Therefore the water pipe lies before all not in the wall, and can also be made safe by a lead lining. Fig. 893 e shows the section of the arrangement.

Entirely similar is made the conduit at Freiburg. As shown by Fig. 892, the wall of the middle aisle is formed of five sides of an octagon, and wall piers stand on the backs of the flying buttresses, furnished below the roof gutter with strongly projecting capitals, so that the area obtained becomes a basin likewise enclosed by the balustrade of the roof, from which the water flows down through the pipe enclosed by the wall pier, and is led to the enclosed pipe forming the back of the flying buttress. Fig. 892 b shows the section of the latter.

The essential difference of this plan from the former consists thus in the more complete enclosure, in the substitution of the enclosed pipe for the open channle. Any advantage can be less found in it, since thereby the removal of any stoppage er made difficult.

From the arrangement mentioned above differs that of the cathedral of Seez seen in Viollet-le-Duc, in that the pier enclosing the pipe instead of standing on the back of the flying buttress, is corbelled out about the height of a course above its junction with the wall, and this corbel is formed by a great lion's head with open jaws directed downward, thus openly casting the water into the channel.

If then in adopting an open conduit is found one advantage, this is even increased by the omission of the front wall of the pipe leading the water down from the gutter, whereby it in a sense takes the form of a vertical channel.

Moreover if an advantage is to be found in the adoption of an

open conduit, this will be even increased by the omission of t the front wall of the pipe leading down from the gutter, whereby this in a way assumes the form of an open channel. Such an example is offered by the cathedral in Regensburg. For here that p projecting pier in which the pipe leads town in the before mentioned examples is replaced by a triangular case open on two s sides, so that two of the same adjoining little columns are next the wall and the third stands free, and the entire form stands on the back of a gargoyle, that casts the water into a channel on the back of a flying buttress. An improvement of this arrangement would be its connection with the peculiar spout at Seez, so that also the point where the vertically falling water must change to the oblique direction is opened.

The opening of two sider of the triangle brings with it the fault, that the water falling inside it may be driven by the wind and be scattered over the roof of the side aisle, without reaching the channel on the flying buttress. By a rectangular form of the conduit with closed side walls this fault could be met, but still better if the duct passes from a vertical to an inclined position, in other words, that the channels on the backs of the flying buttresses are made steeper just before they start at the wall of the middle aisle, then extending close under the proper gutters of the wall of the middle aisle. Such an example is found on the choir of the cathedral of Auxerre. (Perspective view is represented in Fig. 399).

The arrangement mentioned is there connected with another that has substantially the same purpose and is executed in the most varied forms on many mediaeval works. We mean an elevation of a special water conduit resting on the latter. There the ashlar forming the channel are supported like the handrail of a stair balustrade, either by a system of vertical muntins connected by a straight lintel or by arches od various forms, as on the choirs of Amiens and of Auxerre (Fig. 399), or by a balustrade placed at an angle to the direction of the channel, as on the cathedral at Cologne. A simpler form of this kind is formed by the upper flying buttresses of S. Peter Jr in Strasburg. With the arrangement of a series of muntins must the proper flying buttress be covered by a concentric course or by one parallel to the inclined direction of the channel (Fig. 397), on which are then wrought the seats for the muntins. Now that the ashlar

of this course are made so large that each of them supports at least one muntin, each voussoir od the arch receiveu its load and this will ensure it against any rising upward. That in many, even if not in all cases, the upper covering had to serve as a stiffening as well as to carry water as mentioned elsewhere.

Further description of flying buttresses and details.

Line of the arch.

As for what concerns the line of the arch itself, we have already mentioned above the greater advantages of a greater radius, and therefore the adoption of a centre inside the inner face of the wall. After fixing the centre the radius is directly found by the distance of it from the inner face of the buttress, or from the round here given and supporting the flying buttress, which can stand about over the round of the cross rib of the side aisle. Accordingly the line of the arch is vertical at its beginning. Hence the line of the arch corresponds to half a pointed arch and is itself very steep, so that its force at the upper end is directed more or less obliquely upward (Fig. 405); if it is low and thus less than a semicircle in height, its upper force will be quite or approximately horizontal (Figs. 402, 404). The steeper the arch the less will be its horizontal pressure with the same weight, and so muct lower will it be carried down to the buttress. Moreover steep arches can serve to receive a part of the vertical load of the clearstory wall.

But a limit of the height of the arch may seem required by t the general conditions, and will result in lowering the centre and increasing the radius, so that accordingly the flying buttress only appears as a segment of a half pointed arch. Thereby will the proportion of the thrust be so far influenced, that the thrust of the arch falls higher at the junction with the buttress, and is increased with the weight of the arch otherwise remaining the same.

Cross section of the arch.

The conditions on which depend the necessary dimensions of t the flying buttress depends we have already examined above and in regard to what was already stated, there, will be compared h here with each other only two different works. For on the Freiburg minster, where permanence of the arch line is ensured by masonry laid thereon, the depth of the arch amounts to 45 cm

with a thickness of 40 cm, and a span of 8 m, while on the not covered flying buttresses of the Liebfrauen church at Worms is found a depth of 60 cm and thickness of 90 cm for a span of about 4.5 m.

On the earlier works the cross section of the flying buttress is either square or with chamfered angles. Richer sections are shown by those of S. Ouen in Rouen (Fig. 900), and still more ornamental are those of the cathedral of Cologne and of the church of S. Katherine in Oppenheim (Fig. 901 b). A construction with two courses lying on each other like dividing arches is just as superfluous,for the function of the flying buttress as unsuitable to the smaller thickness. On the contrary are found on certain later works added suspended simple or compound arches attached to the lower surface, after the analogy of window tracery.

Besides the economy of the earlier mode of treatment a freer distinction of a sharper characterization is peculiar to them, in so far as they save the richer members for the interiors, for the arches under which men pass, but omit them on flying buttresses turned above the roofs. Therefore such refined members contrast in but limited measure with the mighty swing of the line of the arch and with the great dimensios of adjacent parts of the building.

Coping.

Over the backs of the flying buttresses is a moulded coping, if it comprises no channel, to what is later said on the forms of gables applies, but with the difference that on acconnt of the lesser inclination, the horizontal joints must be exchanged for those perpendicular to the inclination.

Enclosed pipe.

The form is little or not at all changed by placing an enclosed pipe in the coping, as found on Freiburg minster and the c church of S. Katherine in Oppenheim. On the church last mentioned indeed is only visible the intention of such an arrangement by the ashlar a of the external buttress represented in Fig. 901, which should be adjoined by the coping of the flying buttress. Fig. 901 a shows the same in front. On the end piece of this coping b built in the clearstory wall of the middle aisle in Fig. 901 is on the contrary found an open channel, which indeed contradicts the assumed arrangement on the buttress, so that either an alteration of the originally intended arrangement

or the subsequently intended addition of the upper half of the pipe is to be assumed. Fig. 891 b then shows the profile of the enclosed pipe found on the backs of the Freiburg flying buttresses, consisting of two courses. A similar arrangement occurs on S. Barbara at Kuttenberg.

Moreover the plan of the enclosed pipe in this place is chiefly to be rejected, though this in Freiburg still dates from the Early Gothic period, and also seems to have caused no faults in the course of time.

Open channels.

The advantages of such open channels on the flying buttresses consist in the ease by which any accidental obstruction to the removac of the water can be removed, and the need of drying out. Since access to these above the roofs of the side aisle yet remains difficult, then the balance again inclines somewhat in favor of the closed design, by which all stoppage is avoided, if the drying is not also essentially hindered.

The simplest form of an open channel is that in Fig. 893 d. Richer members of it are found on Strasburg minster (Fig. 893 b) and the cathedral at Auxerre (Fig. 899). It must be combined w with an open channel and unite above in a single form of leaf or bud (Fig. 902), or the leaves must be visible at both sides, their thicker parts growing together above the opening. Such forms are found on the cathedrals of Cologne and of Regensburg. On the contrary on French cathedrals the crockets are usually lacking in these cases, indeed even when with double flying buttresses they crown the backs of the lower and enclose no channels.

Junction with the middle aisle.

The junction of the flying buttress with the clearstory of the middle aisle occurs as stated above, either directly or on a buttress carried from the ground or one supported by little columns, whose width usually agrees with that of the flying buttress, thus first on the block of the wall laid on that column, so that the last radial joint of the arch lies outside the supporting impost (a in Fig. 893). That this block must have a considerable depth or be strengthened by ashlars lying on it results from the load of the wall thereon. As a rule it then r remains simply rectangular, so that the members of the flying buttress stop against it, or by a bend extend down vertically

to the capital of the column, yet it may assume a recher treatment. Thus in Amiens blind arches rest on the capital of the column and are wrought in the side surfaces, whereby results o one of the most varied motives capable of execution, while in Cologne the complete system of gables and finials are carried out on it, so that as represented by Figs. 903 and 903 a, the members of the flying buttresses extend down between the angle column and the capital of the column, but at the same time cover the passage by arches cut through the lintel.

The junction of the coping of the back occurs in the same manner, so that the beginning of the members concerned are wrought on a bonded ashlar as shown at b in Fig. 901. With the arrangement of a channel,either its beginning is made in one piece with the spout or gargoyle as in Strasburg (e in Feg. 893), or there must be entire separation as given by the design at Seez explained on p. 392, or at least the gargoyle rests on a pedestal, through which the joint can pass.

The entire mass of the part of the wall resting on the block, against whose front is turned the flying buttress, then forms an opposing masonry adjoining the wall of the middle aisle, and may either terminate under the coping of the flying buttress, or serve as a base for the most varied forms of piers and finials strengthening the balustrade of the roof. Thus either piers may be set on which above the returned roof cornice of which t the pinnacles stand, or the latter directly so that only colossal figures stand at the balustrade of the roof, or giants without bodies rest on the flying buttress, or finally the pinnacles first stand on the roof balustrade as in Strasburg (Fig. 893),. A very beautiful solution is found on the choir of the collegiate church at S. Quentin, where the copings are unrolled at the junction with the wall of the middle aisle, and figures stand on the volutes thus formed, which rest at the face of the wall.

Moreover how buttress walls become analogous to the actual buttress piers, then window arches, gables etc., find their connection as on the latter (Fig. 901).

In regard to the junction of the arch with the clearstory wall, Viollet-le-Duc (Bict. I, p. 64) indicates there that it is important to be bonder above but to form vertical separating joints, in order toeprevent the possibility of slipping, a rupture of the arch by different settlements of the body of the wall. He

asserts that a failure of this free jointing almost always systematically results.

It is to be noted here, that a slip in a stressed arch is to be termed improbable, and that on the other hand the opened joint in movements and especially in variations of wind may prove favorable in a different sense. If in Fig. 904 the usual line of pressure is denoted by I, it will be transferred by wind from the left like II, and on the contrary a wind from the right will form the straighter line III. Thus in some cases the pressure may be moved so far toward the upper or lower edge, that a temporary opening of a joint may occur at the opposite side. If a through joint exists, this may open somewhat without hindrance; if it does not exist, then on the contrary with firmly bonded ashlars a rupture may occur at the points A or B, or if the strength of the materials resists this, a fixed end being assumed, a break of the arch at C.

The procedure is more clearly intelligible, if it be considered not statically but dynamically as represented in the sketches of Fig. 904 a, b and c. Fig 904 a shows the joint opened above by a wind from the left, Fig. 904 b on the contrary below by o one from the right, and Fig. 904 c exhibits the breaking of the arch at its weakest place if dixed at the top.

Proportions of heights of the basilica.

This is in a certain relation to the previously developed structural system, if already the limits derived thereby are very wide. For example if the width of the side aisle = 1, that of the middle aisle = 2, the height of the side aisle =2, that of the triforium = 1, so that the roof has the direction of about 45° and the height of the clearstory = 2, there results for the middle aisle the proportion 2 : 5, that is already to be regarded as a maximum ration, whereby the window sills lie far below the capitals of the rounds, so that in ordinary cases a reduction is required. Such would first affect the height of the window story or light story according to the earlier and better expression. If the window occupies the entire length of the bay between the rounds, as a limit to it may be regarded a raising of the window sill to the capitals of the rounds, whereby the height of the clearstory required by the height of the vaults amounts to about 1 1/4. If we also reduce the height of the triforium to 3/4, then will the height of the middle aisle

correspond to that of the side aisles and be 1 : 2, and can be still reduced by lessening the heights of the side aisles.

Even smaller heights can result frsm smaller widths of windows, for which we can mention the church at Rheims as an example (Fig. 921), where the capitals of the triforium columns lie at the height of the capitals of the rounds, so that the sill of the windows of about 2/3 the length of the bay is moved up to the base of the side arch, and gives a proportion of 2 : 3 for the middle aisle.

Form of the buttress receiving the flying buttress.

The abutments of the flying buttresses form the additions to the walls of the side aisle for the adjacent buttresses, and therefore as a rule are set with their inner surfaces beyond the inside face of the wall, or if the rounds standing there in the side aisle have sufficient size, beyond the inner side of the latter. But since the width of the round is mostly far less than that of the buttress, as a rule there is over it a narrower part of the pier or again a round, which affords the bearing for the flying buttress. However this projection is also usually wanting, and the flying buttress rests on a corbel that projects frsm the inside of the pier, or it starts directly from the latter. Not rarely the upper bearing is corbelled out inward considerably beyond the inside face of the wall or its projection, to more effectually oppose the thrust of the arch.

Conducting the water from the side aisle.

The entire projection in the simplest case continues in play with the lower part of the buttress. In richer designs the cornice of the roof of the side aisle is broken around it, and over this is usually found a projection. Yet where the passages on the roof cornice require openings through the buttress, these projections can only be small or be only placed over the passage. The floor of the opening forms a continuation of the gutter. T The water cay either flow out through a channel extending through the width of the pier and a gargoyle or two set diagonally, or they can be set in the angle between the buttress and the side wall diagonally, or a channel for the water can be carried around the upper part of the buttress, and accordingly the opening through the buttress be omitted, if that channel has sufficient width to make it accessible.

Such an arrangement where the entire length with the balustrade

before the front part of the upper division on the height of t the buttress, that is adjacent to the upper flying buttress, a are set four little columns forming a square and connected by three blind arches, which stand on a projection of the lower part of the pier and form the basis for the pinnacle placed above them. By such an always simple design is obtained a closer connection of the finial with the flying buttress, the decorative effect is enhanced at the same time by the reproduction of the dimensions of the lower pier in the pinnacle, and in a certain sense is expressed the sthuctural idea, that results frequently later in extensively overrich and extremely varied solutions, or appears even less clearly.

However when the system of terminating in a finial had found a complete development, there appeared the endeavor to employ it in the oblong form of that addition, chiefly that of the entire pier and in a more artistic manner. The simple roof of the buttress entirely disappears, and also the surfaces remaining beside or before the terminal pinnacle were divided into finials in the most diverse ways.

Intermediate piers with arches of doubled spans.

For systems of buttresses with double spans, thus over 5-aisled plans, piers stand also above the intermediate piers of the side aisles, which cannot act as proper buttresses, on which rest the upper buttresses and the lower ones adjoin. In the simplest cases these may receive the form of the ordinary vault p pier or of stronger columns. Meanwhile it is also very near to aid the stability by loading, i.e., to give those piers an independent termination rising above the junctions of the flying buttresses, instead of leaving them beneath the coping of the flying buttresses. By the plan of the aisle piers as well as by their function, these intermediate piers will rather take a concentric plan in contrast to the oblong one prescribed for the external buttress, thus the shape of a polygon or of a Greek c cross as in Cologne, whose four wings end in pinnacles, which giants grow up around the terminal pinnacle standing on the central square. This form of motive in Cologne is then extended also to the outside buttress, only being changed in the latter in accordance with its function so that the outer arm of the cross is considerably extended, on the front side of which is placed a separate terminal pinnacle, or rather is projected so

or front face of the buttress or over the middle of its depth. The first arrangement is indeed to be regarded as most preferable in statical respects, since it moves the centre of gravity of the entire mass of the pier nearer the interior, and therefore increases the lever arm of the resistance. Thus is it found on the Freiburg minster (Fig. 89∠). But on the other hand the otherwise sufficiently heavy projection brings the placing of a lighter pinnacle over the front face, as found on many French works, producing for the standpoint of the observer the effect of great firmness, certainly making more apparent the principle of loading. Besides the actual loss in statical effect is only very small.

Placing the pinnacle over the middle of the depth of the buttress is found most simply on the cathedral of Chalons (Fig. ? 898) , in richer form on that of Beauvais. The pinnacle of the last work, with a body consisting of four little corner columns connected by arches thus forming a shrine, which however does not contain a figure as usual, but covers the great pinnacle p placed between the roof of the buttress between those columns, is an arrangement which is then transferred to the original form of the buttresses of Cologne cathedral,(Note), and produces even by the expression of the greatest richness a peculiarly astonishing effect. Yet we might give the preference to that older arrangement, where the terminal pinnacle has an unsymmetrical position. Indeed the entire buttress thereby has a less independent form, but its belonging to the whole is clearly expressed.

Note. Changed at the restoration. See Reichensperger's Miscellaneous Essays.p. 320.

On the buttresses of Strasburg minster, that addition consists of a lower sloping mass, that moves back the centre of gravity, above this being a pier of oblong plan, whose front portion forms a pinnacle (Figs. 893, 393 e). Thus the little corner columns of the pinnacle stand flush with the mass of the pier with bases on the projection of the cornice, so that also in the arches and gables of the pinnacle is a projection and the gaple roof of that part of the pier terminates under the gable of the pinnacle. The strasburg termination must be termed particularly happy, since it combines a good position of the centre of gravity with a clear architectural effect. An allied arrangement is found on the old buttresses of the cathedral of Amiens, where

is broken around the buttress, and which occurs on the choir of the cathedral of Clermont, but also on the towers of Strasburg and of Colmar, leads to an offset also in the thickness of the buttress, whereby only the unusual width of the lower part of the pier is obtained a sufficient area. With ordinary dimensions corbels in the thickness of the pier are necessary, that may either extend on the front side or be replaced there by the possibility of a sufficient offset, but in any case may lead to the richest and most varied forms. If then over the different bays of the side aisle are arranged separate gable roofs, the water from the gutters between them can be carried around the buttress.

Upper termination of the buttress.

What now concerns the upper ending of the buttress, the simplest design of this is a gable roof lengthwise, against the rear gable of which starts the coping of the flying buttress and thereby determines the height. Such buttresses are found on the c churches of Pforta and of Mantes (Fig. 905). The height of the ending can be further reduced by continuing the back of the flying buttress to the front gable, whereby the extra width required for the buttress resistang by its weight the turned arch, and that is already necessary by the condition of resistance, joins the buttress at each side with a wash. Likewise here very different forms are possible.(Figs. 906, 90б).

Then if a channel is found on the back of the flying buttress, the gargoyle may either lie horizontally on the roof op the pier (Fig. 908), or on the top of the pier may be formed a basin, f from which the water flows through a spout placed lower (Fig. 909), or finally the water may pass downward through the roof of the buttress. There substantially applies in all different designs about what is said on p. 362 et seq. Yet we note that the design of the spout on the buttress like Fig. 908 requires very long stones, and therefore a deeper location ensured by the loading results in a substantial reduction in weight.

Added pinnacles.

An increase in the resisting force of the buttress by a greater loading leads in the simplest form to raising the roof of the pier above the junction of the coping of the flying buttress (Fig. 912), but in richer shapes to a horizontal projection or one consisting of several gables above it, or to a great or a complete pinnacle. This additionthen either stands over the back

but the middle vaults have masonry on the cross arches, which in common with the flying buttresses form a strong cross stiffening. One cu. m. of tolerably heavy machine made bricks may weigh 1800 kil. The remainder results from the section in Fig. 912.

It will first be computed how great must be the counter thrust of the flying buttress placed at the height of 18 m with the assumption, that the pressure goes down at the centre of the bottom end of the middle pier.

For the latter point will be established the equation of moments for all forces, that act on the middle pier above the ground with the wall loading it. The forces are the following.

The sought horizontal thrust B of the flying buttress that t turns to the right with a lever arm of 18 m, the thrust of the side vault H_2 = 2160 (p. 154) likewise turns right, and acts in round numbers at 8 m above the floor. The vertical pressure of the half side vault V_2 = 6840, that acts at the side of the dividing arch, thus about 0.39 m left of the moment pivot. The left turning thrust of the middle vault H_1 = 3240 (p. 154), and passes into the face of the wall about 17.5 m above the floor. The vertical pressure of the half middle vault V_1 = 10,260 with a lever arm of 0.39 m and turning right. To these are added the horizontal and the verticalresistance of the masonry on the cross arch. The latter acts with a lever arm of 0.39 m turning right and equals half the weight of this masonry, which with 25 cm thickness and 7 sq. m vertical area amounts to V g = 7 × 0.25 × 1800 = 3150 kil. The horizontal thrust of the cross arch with this masonry turns left and varies with the wind, etc., in favorable conditions it can act at the same height as the thrust of the vault, thus 17.5 m above the floor and turns left, then amounting to about a third of the vertical force Vg, so that Hg = 1000. The weight of the pier with the clearstory wall resting thereon amounts to about 110,000 kil after deduction of the windows, recesses, etc., and is omitted in the calculation, since its centre of gravity falls over the middle of the pier and thus has a lever arm = 0.

According to all this the equation of moments of the forces turning right and left is :--

$B \times 18 + H_2 \times 8 + V_1 \times 0.39 + Vg \times 0.39 = V_2 \times 0.39 + H_1 \times 17.5$ $Hg \times 17.5$.

adjacent parts of the pier must not become entire regularity, rather as there always a certain relation of them to each other to be preferred. Thus on the piers of Rheims the coping of the flying buttress joins the gable roof of the pier, and the latter terminates above the capitals on the shrine with the figure, so that the ridge of the roof ends with the top od the horizontal cornice, and the capitals of the columns are taken from the same course with those forming the rear angles of the pier. Moreover already the plan of their bed joints leads to such a harmony of the heights and the borders conceal the vertical tendency.

Removal of water from the flying buttress.

The removal of water from the channel of the flying buttress, of which we have already spoken, must either be through a pinnacle or be led around the gargoyle projecting at the middle or angle of the flying buttress.

Only on the church of S. Katherine in Oppenheim does the channel passing through the pier divide inside it to both sides, e ending at the sides of the pier, in openings given at a in Fig. 901 so that the water drops over the wash and drip moulding to the gutters of the roof of the side aisle.

By the reparations in the years 1878 to 1889, according to t the statement of Professor Baron von Schmidt at Munich, the old water channel was restored again in all its parts, but the water was conducted in leaders to prevent the danger of leaks from metal piles laid in stone gutters.

Calculation of stability of the buttress system.

Although the conditions of stability have already been stated in the Section on Abutments, it will not be omitted here in the bays of the basilica to give a fuller understanding of the course of the calculation by a simple example.

Example. Calculation of thrust of the flying buttress.

The same example (Fig. 394) on which was based the calculation of a hall church on p. 154 and 376, may now be regarded as pertaining to a basilica to be erected in brick. The vaults may exert the same thrust and weights given on p. 154, the outer walls of the side aisles being only 2 1/2 bricks thick = 65 cm and 11 m high, the clearstory walls being supported by pries of sandstone and have a height of 22 m from the floor to the gutter, but on the contrary having a thickness of 3 bricks = 78 cm, that already exists in the dividing arches. The side vaults have none

that now the buttress receiving the flying buttress has the cross shape shown in Fig. 910 instead of the simple oblong plan.
Similar forms result on the choir buttresses of certain works, like the cathedrals of Cologne and of Amiens from the junction of the chapel walls w th the buttresses, so that as shown by F Fig. 911, these walls are attached to the buttresses as strengthening wings a. Meanwhile this arrangement has the disadvantage, that the buttress has an excessive depth and thereby obstructed the view of the high choir, as well as proved by comparison of the choir design mentioned with that of Beauvais. For on the l latter the buttresses have retained the rectangular plan and thereby have ensured the greater effect of the clearstory, which is even increased, as instead of being planned as a polygon this is a semicircle, and hence the crowning roof cornice with its grand curve represents a complete unity.

Horizontal division of the buttress.

The junction of the back of the flying buttress leads to a h horizontal division or termination of the buttress, and also as a rule is fixed a second division by the junction of the arch itself, thus being the height of its ground line. This principle of a horizontal division of the buttress dominated by the flying buttress is found indeed in the freest treatment on even those of Cologne cathedral, on which verticalism predominates in such a detailed way.

On the contrary we meet with a decidedly different system on the cathedral at Rheims (Fig. 894), where the proper buttress that is joined by the flying buttress stands on a massive small tower, which consists of a solid substructure adorned by blind arches and with columns inserted in the angles, with a colossal shrine of a figure supported by four columns and terminating in a high octagonal spire and four angle pinnacles. There the divisions in the height of the little tower correspond neither to those of the adjacent pier nor to the heights determined by the junctions of the flying buttresses. This system of the attachment of two different portions of the pier, thus a more vertical division is further found, if already less decided on the choir buttresses of S. Ouen at Rouen (Fig. 1083), where the upper flying buttress rests on the lower cornice and its coping at the height of the springing of the arch of the rear part of the pier.

But the inequality of the division in heights of the two adja-

Inserting the values given above as obtained, B = 3020 kil.

Having the required thrust of the flying buttress, then its required weight can be computed, when the equation of moments is established for the probable lower point m, under the assumption that in this case the centre of gravity of the arch and the force G lies about 3 m to the right of M, and the upper point of application is about 5 m above M; G × 3 = 3020 × 5. Hence the weight of the flying buttress must then be G = 5033 kil, i.e., the arch with the loading coping must be $\frac{5033}{1800}$ = 2.8 cu. m in volume, or with a thickness of 1 1/2 bricks = 0.38 m, it must have a vertical area of about 7 sq. m.

It is still possible to construct a perforated arch as shown in Fig. 912 with this small area. If there were practical grounds for a somewhat greater volume, nothing would oppose it with an otherwise correct distribution in the given limits, since t the assumed masonry on the cross arches would offer resistance by its stiffness (increase of Hg) but then the abutment pier w would also naturally require somewhat greater dimensions.

Calculation of thrust with the effect of wind.

It will now be investigated how the flying buttress, whose coping falls 1 to 1 1/2 m below the gutter, acts with a heavy storm of 120 kil per sq. m pressing on the opposite wall.

If it can be assumed that the wind against the roof and wall of the side aisle can be resisted alone by the stability of that external wall, then remains the wind against the clearstory wall and roof.

The wind against a panel 7 m high and 6 m wide of the clearstory wall amounts to 6 × 7 × 120 = 5040 kil, and it has an average point of application at the height of 18.5 m.

The wind against one bay of the length of the roof, that with 60° inclination and 10 m length of slope has an area of 10 × 6 = 60 sq. m, and according to p 163 it amonnts to 60 × 92 = 5520 kil, and is applied at the height of the beams, thus at 22 m above the floor.

The total effect of the wall and roof is then computed at 10,560 kil with about 20.5 m average height. From this is deductid 800 kil in consequence of a small reduction of the thrust of the flying buttress at the windward side, and further the two middle piers together could receive about $\frac{1000 \times 20.5}{110,000}$ = 0.19 m, that without too great edge pressure, that here is not pursued farther,

is indeed allowable (p. 145 and 155). There would still remain the wind presure of about 8000 kil, which is transmitted to t the flying buttress, partly by the stiff cross arch and partly by the roof framework of the side aisle.

This horizontal force is much greater than the ordinary thrust of the flying buttress, it would press upward and destroy a simple arch, and it can only be received by the inclined upper coping, which moreover by its high junction against the upper clerestory wall receives the wind where it acts, and thus keeps f from the pier the vibrating overturning moments.

The wind pressure W = 8000 kil and divides into two components (Fig. 912 a), one component falling in the direction of the strut and with the inclination of that at 45° amounts to 8000 × $\sqrt{2}$ = 11,314 kil, the other being berpendicular to the former and directed upward and results at 8000 kil, opposing the weight of the clearstory wall and roof with its vertical wind load, and it opposes a high pressure of those parts. The larger force of 11,314 kil coinciding with the direction of the coping of the arch must be safely conducted downward by this coping. It is assumed that the danger of bending or bulging is not to be feared in this case, and thus only the question of the resistance of the cross section to compression at x x is not in question. If with construction in bricks and lime mortar 7 kil per sq.cm is allowed, then the cross section is $\frac{11314}{7}$ = 1616 sq. cm, and thus with an average width of 38 cm it must have a depth of 42.5 cm. Construction of this part with cement mortar or by the use of cut stone, these dimensions could be somewhat reduced.

Calculation of the buttress.

Now to be examined is the stability of the brick pier receiving the flying buttress, which for a fixed height of 18 m and a thickness of 1 m may have a lower depth of 3.2 m and an upper one of 2.4 m.

On the buttress act the vault thrust of the side aisle, the thrust B of the flying buttress and the horizontal thrust W = 8000 kil exerted by the coping of the flying buttress during wind (Fig. 912 b), as overturning forces, transferring the following moments to the area of the pier at the height of the floor

Side aisle, 2160 × 8 =	17,280
Flying buttress, 3020 × 13 =	39,260
Coping with wind, 8000 × 15 =	120,000

Total overturning moment = 176,540.

For the still unknown point of pressure in the ground area which may lie X m from the rear edge is establisred the equation of moments, the overturning moment just obtained being placed equal to the favorable moment of the vertical forces. The vertical forces are the following:- 1, weight of the buttress, that with 18 m height, 1 m thickness and 2.8 m average depth has a volume of 18 × 1 × 2.8 = 50.4 cu. m, thus weighing 50.4 × 1800 = 90, 720 kil, while its centre of gravity lies 1.4 m from the inner edge; 2, weight of the part of the external wall adjoining the buttress, which with about 20 cu. m volume weighs 36,000 kil, while its centre of gravity lies 0.32 m from the inner edge; 3, the vertical force of the vault of the side aisle acting at the inside face of the wall, that as noted above amounts to 6,840 kil; 4, the weight of the flying buttress of 5,033 kil acting at the rear side of the buttress; 5, the vertical component of the pressure transmitted by the coping (Fig. 912 b) which amounts to 8000 kil, and can be regarded as acting at the inner side. Thus the equation of moments is:--

$$90,720(X - 1.40) + 36,000(X - 0.32) + (6,840 + 5,033 + 8,000) X = 176,540.$$

Thereby is computed the distance X of the pressure from the inner edge, and X = 2.15 m.

The pressure already lies somewhat outside the kern, but it is still distant 1.05 m from the outer edge. The sum of all vertical loads resting on the ground area of the pier is computed at about 150,000 kil, and the average pressure amounts for about 4 sq. m of bearing ground area of the pier and the adjacent wallto $\frac{150000}{40000} = 3.75$ kil, and the edge pressure is somewhat more than twice this average pressure, thus being about 8 or 9 kil per sq. cm. This stress in all cases can only exceptionally be allowed for good brickwork; if it is believed that the masonry must not be so strongly stressed, then the pier is to be made somewhat deeper and must then be calculated anew. In our calculations the wind pressure is taken at the established magnitude of 120 kil per sq. m of exposed surface; if in consequence of better investigations or of local conditions, greater or smaller values are to be taken, then will the final result be changed to correspond, but the nature of the matter will remain the same. The wind against the clearstory of the basilica should never be

assumed too small, since this usually rises above the neighboring buildings, and moreover the wind is raises by the side roofs against the clearstory. When no wind acts, according to the evidence of the equation of moments now as before established, the pressure lies nearer the centre of gravity of the ground area, so that a nearly uniform distribution of pressure results, nowhere far from the average pressure, that amounts to about 4 kil. If the middle pier is made very slender so that it is unable to receive a part of the wind (as assumed above), then its portion would fall to the buttress, on which then would act a side force of 10,000 instead of 8,000 kil, which would make it necessary to strengthen the pier. Then for the basilica as well as for the hall church (p. 375), the external buttress can take the place of the middle pier, uhen a correct cross stiffening by the middle vault and flying buttress is cared for.. Conversely a very strong middle pier may take the place of a too weak outer buttress. One can generally assume that a correct transverse stiffening that the basilica is stable, if the two middle piers and the buttress opposite the wind are together sufficiently stable.

General remarks on calculations.

Nothing prevents extending the calculation with greater accuracy to further details, which is here made in form as approximate as possible, particularly in following the entire course of the pressure in the middle piers and clearstory walls, including, the framework of the roof, side arches, passages, etc., to test the behavior of the flying buttress and of the masonry on the cross arches in varying strengths of the wind, determining the important enlargements of the plinth and footings by calculation etc. This edition of the Manual has given indications for this in different places, so that it must not be difficult for the designer with some circumspection to satisfy himself properly concerning details and peculiarities, that only appear in a worked out design.

Here comes to us the fear first of all of seeming in any manner to strive for theory and of rejecting to seek for easy ways both for accurate as well as for approximate calculations, thereby showing that we had not yet seen correctly the static conditions of such works, that in contrast to the old masters we had been too much accustomed to take account of the quiet forces, thrusts of vaults, etc., while in quite particular magnitude

are the varying stresses by wind, etc., to which must be devoted especial attention. Reference is again made to the fact, without wind thrusts if necessary, that our greatest basilicas could be erected without flying buttresses, since then by corbelling and weighting the masses equilibrium could always be attained.

Many of our statements are first attempts, it must be confessed, which it is hoped may be further perfected. In this opportunity unfortunately we cannot fail to remark, that many ground factors on which our calculations must be based, require further explanations, and to these belong the allowable limits of stresses, the elasticity and resistance to bending of the kinds of stone and mortar, the pressure of wind, its effect of impact, its diversion and its gliding on inclined surfaces, and many other matters. Recently it is gratifying that theorists and practicians appear to turn rather to these domains.

4. Development of the Triforium.

Section of the triforium.

Fig. 913 represents the cross section of the church with buttress system, as it results from the preceding, and at a is the passage arranged before the clearstory windows, the triangle d b c is the roof of the side aisle, and e is the little column supporting the flying buttress, which stands on a pier carried through the interior of this roof. If we now base this on definite dimensions and calculate for the widths in the clear of about 9 and 5.5 m, for the middle and side aisles, the pier 1.35 m wide, the projection f g as 30 cm for the round above the capital of the pier, a window wall h i being 45 to 50 cm, width of passage a 40 cm and the column e 30 cm, the total width e x is about 1.5 m, and hence the necessity of either corbelling out the pier supporting the column e, or setting it on the springing of the vault of the side aisle, by a distance which increases with the reduction of the width of the aisle and the width of the lower pier, since the width of the passage must be constant.

Accordingly as our Fig. shows, there results at the height between the crown of the dividing arch and the floor of the passage a thickness of the wall of at least 90 cm, and about 1.7 m for the aisle pier at f k, since the column e also has a base.

Economizing the wall by a triforium.

Then if such a thickness of the pier above the passage and

through the buttress system would be superfluous, it is at least of the same dimension at the height of the joining of the roof. No les superfluous is that heavy thickness od the wall on the dividing arches, since it becomes actually injurious by the loading, and the thrust of the dividing arches is substantially increased thereby, which may even compromise the stability of the crossing piers. We shall only mention here, that the weight of such a wall mass is more than six times the part of the vault loading each pier, and that to us has appeared on a new building even before completion an important danger resulting from neglect of this increased weight. Reducing this wall mass therefore seems directly, lessening the thickness above the pier as at least indirectly required. Both requirements would be expressed in the most commonplace way to an eye as avoiding economy. But the open demonstration of all structural conditions forms the life principle of Gothic architecture, and it has in this case led to the arrangement of a passage opened to the middle aisle within this thickness of the wall, i.e., to the triforium.

Placing the back wall of the triforium.

Now assuming in Figs. 913 and 913 a the floor slab of the upper passage as extending through the thickness of the wall beneath the window sill course, the triforium is formed by an arcade standing on the inner ends of these slabs, which is placed on the horizontal cornice above the dividing arches, and t the walls closing the passage at the outside. If we now assume for the arcade, passage and back wall thicknesses of 30, 45 and 30 cm, which are to be regarded as about minimum dimensions, t there results a thickness of 1.35 m, which the width of the dividing arches exceeds. Therefore occurs the need, according to the total dimensions, for extending the back wall of the triforium entirely or partly between the piers above the junction of the compartment turned against the dividing arches and placing thereon a concentric arch, so that their weight will be transferred to the rounds in the side aisle. This necessity disappears, as results from what is said on piers, with a widening of the dividing arches resulting from the total dimensions. To illustrate this we add in Fig. 913 a a perspective view of the entire construction.

As the cross section in Fig. 913 b shows, the window wall projects beyond the outer face of the triforium, on account of its

greater height needing a greater thickness than the columns of the triforium, and rests on the floor slabs of the upper passage. But the unequal thickness assumes an entire separation of the columns of the triforium from the mullions from the window, and ceases when the triforium is treated in a sense as a continuation of the window wall. For strengthening, the arrangement of a second course is preferable, or at least the separate ashlars laid from the columns to the back wall, which naturally lie under the joints of those slabs. Then in the upper surfaces of these are cut little grooves under the joints mentioned, which conduct any water flowing through them to the outside. The roof of the side aisle joins beneath the projecting moulded edge of these floor slabs, which then is also broken around the pier, as seen at a, Fig. 913 b, indeed in a direction following the slope of the roof, thus also ensuring to the latter the junction with the roof. The height of the roof and hence also that of the triforium dependent on it as a rule results greater than seems required by the passage leading through the pier. For connecting the halves of the pier separated from each other by the passage are therefore placed the tie stones b in Fig. 913 b over the height of the passage, and the space over them can be walled up.

Elevation of the triforium.

Relation between triforium and window.

The stone beams according to the usual arrangement are replaced by arches extending from column to column, to whose form as well as position of the columns with regard to the side arch r rounds, there applies what is stated on arcades. This simple uniform row of columns connected by arches predominates in the e earlier works, as in the cathedrals of Laon, Soissons (Fig. 915), Rheims, Chartres, Notre Dame at Dijon, and on the cathedrals of Limburg and of Bonn in Germany. Instead of simple columns are sometimes piers composed of several columns, as in the choir of S. Benigne in Dijon, or mullions without capitals continuing the mouldings of the arches, as in the aisle of the same church (Fig. 916). The smaller height of the triforium then causes that the number of divisions exceeds the number in the window above, and indeed first so that a direct relation does not occur. Thus in the choir of Rouen is found a triforium in 6 divisions below a window in 4 parts, while usually as in Chartres and Rheims, the former doubles the number of the divisions of the latter. But

also the already mentioned difference in dimensions in the separation between window and triforium excludes the necessity of placing window mullions over the column of the triforium, if already from a certain relation of both parts is to be sought the advantage of a uniform division; the endeavor to bring them into harmony therefore leads to divide the arched openings of the triforium into main and subordinate divisions, i.e., to first arrange larger middle and wall columns, connecting these by arches dividing the spaces thus formed by smaller columns connected by arches, then employing the system of large and small window mullions (Figs. 917, 918). Beneath the window in 4 divisions in t the aisle at Amiens the triforium consists of two such groups each composed of triple divisions. The important height of the triforium already caused by the steeper position of the roofs of t the side aisle might make such an arrangement advisable, by which the excessive height of the columns would best be avoided.

On the choir at Meaux the considerable relative height of the triforium resulting from the small length of the sides of the polygon even leads to the combination of both groups under a c common pointed arch, an arrangement that naturally would be impossible with a greater length of bay. The combination of window and triforium becomes particularly intimate, when either a doubling or an agreement of the number of divisions exists, but always the larger columns of the triforium stand beneath the larger mullions of the window. The system of forming groups then leads in the triforium either to alternation of larger and smaller columns, as in S. Gudule at Brussels (Fig. 917), or to a division analogous to the window mullions in a compound system.

Now since by the alternation of large and small mullions the thickness of the window wall becomes unequal, it may appear indicated also to enlarge the little columns in the front wall of the triforium standing beneath the larger mullions to harmonize with the latter. Therefore the window and triforium are brought more into accord, so that the large window mullitins extend down to the sill of the triforium or to the capitals of the larger columns of the triforium.

Therefore in the first case, if Fig. 918 a represents the plan of the large window mullion with the indicated smaller ones, the first also corresponds to the primary and the second to the secondary columns of the triforium. But the small as well as the

large window mullions also contain the inside moulding forming the groove for the glass, which in this form is superfluous on the columns of the triforium and correspond to the little column c on them. The latter then in the development of the elevation of the triforium can only be utilized for the arrangement of little tertiary columns c′, which also leads to the subordinate division not existing in the window, i.e., to the doubling of the number of divisions of the window for the triforium. Accordingly the window sill receives only the thickness of the small mouldings, and the projecting edge moulding either extends down to the lower column of the large support (Fig. 922) or is broken around it. Examples of such triforiums appear with windows divided in 2 parts in the cathedral of Beauvais (Fig. 847), with tose in 4 parts in the nave of Chalons (Fig. 918) and the minster of Strasburg, with 3 parts in the transepts of Chalons.

We call attention here to the peculiar corbelling out of the columns of the large mullions in the last Fig IX, which has its reason that in the transept the corresponding columns at the wall jambs do not stand on the floor of the triforium as in t the side aisle (g in Fig. 918), but extend down to the floor of the nave (Fig. 919), and therefore only these corbellings were to be obtained as bases for the equally projecting middle column.

Combination of triforium and window.

In late works always increases the endeavor to make the triforium a continuation of the window. We mention instead of many only the example of S. Peter in Louvain, where the window mullions extend in completely unchanged form through the cornices denoting the sill of the window and the floor of the triforium even down to the dividing arch, naturally as blind mullions between these and the triforium. Below the cornice they are connected by arches with cusps and above the floor of the triforium is a tracery balustrade consisting of separate quatrefoils.

The colonnade of the triforium in the nave of the cathedral at Rouen is replaced by segmental arches turned between the inner piers. (Fig. 920). But the effect of the whole is violent in the sense with all its originality.

Triforium with smaller width of window.

We have hitherto described the arrangement of the triforium only for those wide windows occupying the entire length of the bay. For a smaller width of the window the colonnade can either

stand beneath the wall surfaces remaining beside the window, as on a little church at Rheims (Fig. 921), or only within the width of the window. The latter arrangement in combination with the before mentioned extension of the mullion-columns of the floor of the triforium is found in Notre Dame at Chalons (Fig. 922) and S. Remy at Rheims.

The close spacing of the little columns serves at the same time for the complete safety of those passing along the triforium, and therefore at least on the older works as a rule no balustrade is placed between them, but sometimes instead of it the plinth of the columns is raised above the floor, that is either effected by raising the moulding over the didided arch, by a steeper wash, or finally by the arrangement of a low parapet wall above it. But the omission of the little columns, as in the cathedral at Rouen, entails the need of a balustrade.

Window over the back wall of the triforium.

When we proceeded before from the assumption of an external passage before the clearstory windows, the triforium is also still found with the same right, if that upper passage lies in the interior, as on the churches of Burgundy, and there is only the difference that the upper window wall is placed above the back wall of the triforium, and therefore all relations between its columns and the window mullions vanishes.

Simplified designs.

With lesser proportions of height or simpler construction there also indeed disappears the passage and with it the colonnade of the triforium, and there is found inside passage entirely open over the dividing arches. Such a design is shown by the church of S. Maria at Lübeck, where this passage has a tracery balustrade. A further simplification of the system is shown in the same church, where also the openings through the piers vanish, so that the separate balustrades over the divided arches are only connected through the attic over the side aisle, into which they open by doors. If now in the present case according to all probability a concession is to be sought to brick construction, then also in stonework the smaller dimensions of the whole and hence also of the piers, make those openings impossible. Therefore are found on the triforiums of S. Ouen in Rouen, otherwise constructed with columns after the usual system, the same arrangement as at Lübeck. In the very clever way in the

cathedral of Limoges, likewise avoiding the opening through the pier, and then the passage of the triforium leads around it in a corbelled semicircular balcony above the vaults of the side aisle. The upper passage is then found on the platform covering this balcony, and accordingly there also disappears the opening in the upper pier, as well as the arrangement of that external free column, and hence the flying buttresses rest directly on a buttress projecting from the upper face of the wall.

A further reduction of the design of S. Ouen and in a sense that of Lübeck is found in certain German works, where the window jambs and mullions, yet the latter only in half their plan extend down to the wash of the moulding over the dividing arches, and the attic over the side aisle opens to the interior through doorways between the blind mullions. While there also those attics serve to connect the separate divisions of the triforium with a passage, they here directly form it.

Strictly taken, logic is here in favor of the last arrangement, yet otherwise the effect of that high window of the middle aisle with its lower half blind and directly above the dividing arch is far below that, which results from the insertion of that row of columns as the richest conceivable frieze in purely formal conception, which by the contrast of the columns of the triforium with the piers of the nave and the rounds, the graceful arches of the same with the wide spans of the dividing and window arches, the greater part first reached its full effect or was thereby enhanced, this would be clear even without consideration.

Moreover the motive of the insertion of such galleries of columns between, over or under higher stories with greater designed parts is one of the happiest occurring in the history of architecture, and beside the position designated here, also reappears elsewhere frequently in churches and secular buildings. We refer to the Tuchhaus in Louvain, where it extends beneath the windows of the pricipal story. Even the form of the doge's palace in V Venice might be referred to it. But the root of this arrangement is to be sought in those so-called dwarf galleries above the s springings of the vaults which characterize the Romanesque buildings of the Rhine provinces.

Triforiums with windows in the back wall.

Triforiums in the choir and transverse aisle.

If triforiums originally came from the plan of shed roofs over the side aisle, they are also found on those parts of buildings where this cause is lacking, executed in complete or slightly changed form. Indeed they must exist thereby to attain the connected purpose of securing a passage. Such parts of buildings are the choir and the transepts for plans with a single aisle, but also the gable walls of the west end and of the transverse aisle. Only here the absence of the roof leads to the plan of windows in the back wall of the triforium. The latter then correspond in their arrangement either to the arched openings of the triforium, so that they reproduce them externally with the addition of glazing and the parts required thereby, they are in a different form, or finally are also arranged according to a different system. Thus on the transept gables of Rheims the back wall on each of the three triforiums spanned by round arches, but in the choir of Notre Dame at Dijon the entire back wall behind the triforium divided in two parts is opened by a great round window, while at the west side of the transepts at Compeigne is found the peculiar arrangement represented in Fig. 923, whereby there is found in the back wall behind the three arched spans of the triforium two pointed arched windows separated by a slender middle pier, and further for the first arrangement is afforded by the example in that transept at Chalons represented in Fig. 932. It may be that the similar division is more favorable to the effect of the glass painting in these windows, and thus we must award their rights to the contrasted lines obtained by a diversity of the system as in Dijon and Compeigne.

Transfer of the windows to the triforiums of the nave.

The magnificence of the painted glass by which the triforiums described above outshine their sisters in the nave might then lead to the endeavor to ensure to the latter the same effect. But in the nave the design of the window compelled a change in the roof, thus either a substatute for the shed roof or a terrace as in Oppenheim, or by a gable roof with a gutter arranged along the clearstory wall as on S. Denis and the Strasburg minster.

If it was then a little too strong to alter the entire design of the roof, and to transform it into a form less advantageous for the easy presentation of the entire building, as at least the latter certainly is, only to obtain the effect of some stained glass, for which the entire system of the building otherwise

offered sufficient space, then shall we see how this arrangement of the roof led to the omission of those parts for which they originated, for in both was lacking the determination of the h height of the triforium, and therefore the particular cause for its existence, and no reason existed longer, not to continue the window down to the terrace or the gutter existing between the roof and the clearstory wall. If then the height so obtained a appeared too great, it could be reduced and moreover the height of the middle aisle, thereby securing an actual advantage in material respects, whereby indeed the interior became poorer and the effect approached that simple arrangement of an equally high aisle with two rows of windows over each other described on p.356

As an example of the last kind with gable roofs still belonging to the 13 th century, we mention the cathedral of Toul (Figs. 850, 850 b). The same arrangement in connection with a terrace is found on the church S. Katherine at Oppenheim dating from t the 14 th century.

Thereby the terraces over the side aisles in Oppenheim, this most convenient means of communication, lead to the omission of the passages fulfilling the same purpose. Meanwhile with the plan of a gable roof and the thereby required gutter for water along the clearstory wall formed a passage and ensured access to the windows of the middle aisle, as then generally the gutter appeared in the place of the upper passage above the junction of the shed roof, and could be formed about as in Fig. 924. But we admit ourselwes unable to mention any example of this kind.

5. Vaulted galleries over the side aisles of the basilic

The galleries of the basilica differ from those of the hall church (p. 381) only in this, as shown by Fig. 926 b, that above the arches by which these galleries open into the middle aisle, still is the height required by the shed roof and the clearstory, but on the exterior and above that roof are found the flying b buttresses.

Openings of the galleries into the middle aisle.

We have already referred above (p. 382) to the arrangement of altars in those galleries, whereby these are elevated above the importance of balconies and assume a more iddependent position. Accordingly as a rule there is found in the most important works of the kind, like the cathedrals of Laon, Noyon and Paris, collegiate church at Mantes and the cathedral at Limburg, the arran-

arrangement leertainly explained by esthetic reasons, that the span of the arch is divided into smaller openings by one or two columns. These esthetic reasons consist in that the repetition of two nearly equal arched openings over each other, as the elevation of the nave of Rouen (Fig. 920) shows, where however the galleries behind the upper arches are wanting, an ugly and tiresome effect must be produced. The arrangement of little columns is so developed in Mantes most beautifully from the members of the dividing arches and that corresponding to the main piers, that these columns and the arches connecting them as well as the tympanum resting thereon correspond to the lower ring of the dividing arches and the rounds supporting the latter, and hence the membering of the lower pier is entirely the same as that of the upper (Figs. 926, 926 b).

Vaults of the galleries.

The vaults of the galleries mentioned as a rule correspond to those of the side aisles. Only in Mantes do we find in a very peculiar way that the bays over the choir aisle are spanned by radiating tunnel vaults. These tunnel vaults are almost constructed after the antique fashion on stone beams, that are supported by two little columns standing on the lower cross arches. The trapezoidal plans of these bays then led to no raising of the tunnel vault externally, but by the horizontal position of the top and a prigressive alteration of the arch lines, as represented in Fig. 926 d.

But there the side thrust of the first tunnel vault at the beginning of the curve of the choir is met in a very skilful way in that the bay spanned by the cross vault, the quarter of the compartment concerned is transformed from the cross vault to a tunnel vault (Fig. 926 b).

Over the choir aisle the arched openings of the gallery then become so narrow, that the division by columns in front is impossible. But still this system is expressed, by the insertion of a smaller arch within a higher one, whose members correspond to those of the dividing arches in the nave, and thereby as Fig. 926 a shows, coincidence with the lower dividing arches is avoided. Over the gallery then lies the roof on the wall of the middle aisle, and thereby is given the motive of the passages and the arcades in the triforium, just as by the ordinary cross section without galleries over the side aisles.

Passages above the galleries.

Since the purpose and origin of these passages is nowisi connecbed with that of the galleries, the existence of the latter affords no ground whatever for their omission, and the cathedrals of Laon, Noyon and Limburg show, that these little arcades between the arches of the gallery and the window story produce a very tasteful effect. Indeed in the works mentioned the arches of the gallery are divided by only one little column, and not by two as in Paris and Mantes, thereby avoiding all competition with the arcades of the triforium. In the cathedral of Paris was found a different arrangement in the original building (Viollet-le-Duc, II, p. 289), which substantially amounts to the same thing and produces a triforium almost purposely like that mentioned above.

Although here especially the hoof over the gallery is made so flat, that it does not afford space for a triforium, so that this is obtained by making the arches of the gallery opening i into the middle aisle and thus the junction of the same cross vaults much lower than the outer side arches of the same vaults, about as shown by the cross section shown in Fig. 889. Only no passage in the height thus obtained is formed in the thickness of the wall, since in general the entire buttress system was not intended for such, though the space over this depression of the gallery vault afforded such, which then received great round o openings connected with the middle aisle and filled by simple tracery. In the church of Mantes, whose section is shown by Fig. 926, the buttress system is likewise calculated for no passage in the triforium, and the dimensions are so moderate, that an arrangement as in Paris could not be executed. Besides the construction of the entire church is very simple and particularly recalls Romanesque architecture by the small size of the windows.

By the arrangement of vaulted galleries the piers and walls of the middle aisle further obtain greater safety, that in Paris is even increased by the flying buttresses above the vaults and still beneath the roof. But further this has led in the works mentioned to a lesser height of the upper clearstory, so that only single flying buttresses are found above the junction of the roof of the gallery.

Galleries in the transepts.

If we now ask concerning the influence of the galleries on

the form of the transepts, no conclusions are given by the French works named, for in Mantes the transverse aisle in general is wanting, but is single-aisled in Paris and Noyon, and hence galleries are lacking therein, or rather those placed over the side aisles between the nave and choir open into the transverse aisle just as into the middle aisle, without being connected w with it. Also even the usual plan of transepts with several aisles, this connection before the gable walls could be made only by open galleries above as in Laon. Extending the side aisles around and thus the vaulted galleries on the gable walls are found nowhere. Therefore the gable walls are only carried so far in sympathy with the design of the galleries, as these have double window stories over each other and above the triforium, While they are removed from all such influence in Paris. Only the cathedral in Limburg shows in the peculiar construction of its choir and transverse aisle at least a substitute therefor. The two last parts are surrounded by side aisles and passages, which are only half the width of the side aisles in the nave, and also but a fourth the width of the middle aisle, since the vaulting system of the hexapartite vault is of square form. Over the angles of this gallery on the transepts rise then two towers flanking the latter. Accordingly as shown in Fig. 925, the system of the form of the cross section in the transepts appears in the same way as in the aisle. But the possibility of this construction is based on the plan of the vault explained on p 414, by which a pier stands at the middle of the gable wall, a and was dropped in the plan of the ordinary cross vault, or rather must lead to the arrangement of a balcony open above and in connection with both galleries, as found in Laon.

6. Cross section of simple choirs, transverse aisle and gables of the basilica.

Choir.

Extension of the window of the triforium.

As before stated above, the entire division in height, thus the widdow stories of the middle and side aisles and the triforium, also in the single-aisled portion, so that also here if a passage is found before the lower windows, two internal and one external passages are formed according to the usual system.

Triforiums.

Each lower passage, that otherwise is usually wanting because

of the small height of the sills of the windows in the side aisle, and that is to be regarded rather as a peculiarity of certain regions like Burgundy, Champagne and the upper Rhine, results in the choir in a certain way from the arrangement of the triforium, in so far as represented in cross section in Fig. 9 ., it was elsewhere necessary to turn an arch b between the buttresses, which then changes place with the lower window wall, so that the arrangement shown in the side Fig. 9 / a results w with a lower passage a. As examples of this kind we mention Notre Dame at Dijon and the cathedral at Regensburg. From Fig. 927 also an external passage could meanwhile be constructed.

If now in Fig. 927 a, as this is also the case in Regensburg, and is likewise first results from the construction, the floor of the triforium is only formed of slabs laid from the arch to the window wall, there results one of the cases mentioned on p 351, according to which the pointed form of the window is not exactly the one required. Yet it is found in Dijon, but in one panel and without mullions, as then also in the middle aisle t the horizontal termination is only obtained by placing 3 smaller pointed windows side by side (Fig. 848). On the contrary in Regensburg the square inclosed by the buttresses and that floor slab is filled in the richest way by arched tracery, whose scheme consists in a pointed arch spanning the separate divisions by mullions, so that above the spandrels and below the disk it is opened in other forms of tracery.

In Notre Dame at Dijon as in other churches of Burgundy, the windows do not extend down to the floor of the passage as in Regensburg, but are rather raised above it by a plain wall surface. In the choir of S. Benigne at Dijon is then found a further reduction of the system, so far that the lower light stories, and hence also the passage appertaining thereto and also the upper one found above the triforium are omitted, so that the projection of the latter from the window wall is found covered by a wash.

Likewise there is sometimes wanting as in S. Leger in Soissons the window in the back wall of the triforium, so that both light stories on the exterior are separated by a plain wall surface corresponding to the height of the triforium.

Transepts.

What is said on the plan of a choir with single aisle applies in the same way to the longitudinal wallu of the transpts and only according as a rule the length of the polygon axceeds the length of the bay, is the number of the arches of the triforium and also the width of the window increased. Hence the length of bay in the transverse aisle always is less than in the middle aisle, as the case in Chalons, where the windows are divided in the former into 3 parts, in the latter in 4.

Rounds and buttresses.

By the junction of the single-aisled transverse aisle with t the three-aisled nave results certain special arrangements of rounds and buttresses to which attention is here called.

For example Fig. 928 is the plan of such a part of the crossing arranged about according to the system of Chalons, therein a being the crossing pier, b the opposite wall pier, c the side aisle, d the middle aisle, and passages are to be arranged before the windows of the side aisles, which then continue before the lower windows of the transverse aisle. Now the wall pier at e requires three rounds for the wide cross arch supporting the upper wall, while the simple cross arch meeting it at f only needs a single round. To equalize the resulting inequality of the number of rounds on the sides c g and f h and at the same time produce a regular plan of sufficient strength, at the angle h project two rounds but only one at the angle g. From the former then extends down to the floor the round 1, as well as the corresponding 2, that bears the cross rib, and since the latter in the transverse aisle already rests on the round 3, they form the outer columns of the wall pier (Fig. 919), so that for the middle one with the same projection there is lacking a base, and therefore occurs the previously mentioned necessity for corbelling them. (In Fig. 919).

By this peculiar arrangement is then solved the inharmonious contrast of the single-aisled to the plan with more aisles in the happiest manner, while the next bay of the transverse aisle, whose upper wall above the dividing arch l m exactly like the middle aisle, of which Fig. 918 represents a bay, comes to stand over the dividing arch h o, so that thus here corresponding to the round 1 and likewise to the rounds 5 and 8 continued in the window mullions, which belong to the dividing arches, extend above these in smaller size as seen in Fig. 918 at g, and accom-

accompanying the window mullions, but here the corbelling of t those belonging to the middle mullions makes equally projecting little columns superfluous.

By reason of such peculiarities, that are never capriciouson medieaval works, it is necessary to call attention to this not entirely banished conception, which see in caprice the nature of Gothic architecture.

If we now return to our Fig. 928, then i k gives the thickness of the upper window wall and of the larger columns of the triforium, so that the dotted lines s s x determine the width of the triforium and the thickness of its back wall.

Over the junction of the side aisles or of the side choir, the pier in question between the two windows, only aside of being reduced by the passage, receiving the diameter i k + k t is nowise sufficient to oppose the thrust of the vault, but for the plan of a buttress at right angles standing at this place, a s sufficient basis is lacking on account of the passage. For this reason the pier in question in Notre Dame at Dijon is set diagonally, a position that is certainly peculiar above the junction of the side aisle, and its appearance is not explained at the first glance.

If we now assume that the passage before the lower windows resulting from the plan with single aisle is found only in the transverse aisle and not in the side aisle, then occurs the arrangement of the changed buttress, closing at the same time a part of the window of the side aisle concerned, or the necessity of a flying buttress, that however strikes the side of the nearest buttress, and hence either a strengthening of this or a wider span to the next buttress is required. All these differences would be solved in the easiest manner by the plan of a hexapartite square cross vault adjoining the middle square, occupied in Fig. 928 by the two oblong bays of the transverse aisle, whereby at f would strike only a bisecting rib, whose thrust is substantially less.

Gable Wall.

The various divisions in height continue in an entirely similar way, at least on the larger and perfectly developed designs, also on the gable walls of the transverse aisle. With the adoption of the system of bisecting ribs for the parts concerned, as at the cathedral of Limburg and the collegiate church at

Wetzlar (Fig. 936), also as Fig. 929 shows, the outer bay of t the transverse aisle is divided in 7 parts, and there generally results for these gable walls substantially the same arrangement as for longitudinal walls, so far as their width is now divided in two parts, each of which nearly corresponds to the former side of a bay. But with the dropping of this Early Gothic arrangement the changed proportion of width leads to a certain peculiar form of window story.

Upper window story.

What first concerns the upper window story is, for the general proportion of it to be an approximate equality of width and height, or even a predominance of the former, and hence the design of a pointed window filling nearly the entire width and divided by mullions, on which the ground line of the window must be that of the vault, would be made substantially heavier. It is here the ratio of the space, which on the assumption of a more concentric plan of window first indicates that of the wheel window, aside from the fact that it also in purely formal respects is the most suitable to place in the different architectural form of this gable wall.

Wheel window.

The first arrangement consists in placing the centre of the wheel window at the height of the base of the vault, whereby there is a crescent area between the circle and the side arch and between the circle and the covering of the triforium remain two spandrels, which if the radius of the circle does not quite agree with the height of that covering from the top of the capital of the round, would be stilted by a rectangle. On the older works like the cathedral of Rheims and Notre Dame at Dijon (Figs. 9_3, 9_4), the surfaces of the differences inside and outside are plain walls and essentially contribute to the quiet effect of the whole. Those crescent surfaces above are then on the transepts of the cathedral of Amiens therefore made higher, so that also the side arch is a stilted semicircle, and hence the horizontal diameter of the concentric wheel window is raised by the amount of this stilting, and thus the whole requires a lesser height. But the last consideration did not control in Amiens, but exclusively that of a perfect solution of those difference surfaces.

But on most works the wheel window is set in the pointed side

arch, so that those crescent surfaces above are either simply opened or are filled by forms of tracery. The omission of the lower spandrel was then easily effected in the same manner, and meanwhile was made essentially more difficult by the addition of that rectangle, which men could not decide to leave unbroken on the richer works. To fill the latter was offered the arrangement of a system of mullions. We believe that it can be assumed from several analogies, that in modern times the solution in question would have chiefly consisted in this, that the parts of this filling divided by mullions and spanned by pointed arches could have been adapted to the circle by increasing the heights at both sides like organ pipes. Such an arrangement causes a monotonous and bad effect with a greater number of the divisions. But in the middle ages the sense of form was far more developed than at present.by the continual consideration of correct art works, and accordingly the design was richer. And just in the solution of such small difference areas is expressed most clearly the peculiarities mentioned. Therefore we cannot omit a reference to two entirely different species of the arrangement in question.

Thus on the transverse aisle at Amiens belonging to the 14 th century, that rectangle under the circle is separated by a horizontal division, and below this by a system of 8 pointed bisected blind arches, but the spandrels by two corresponding to two of those and filled to the circle. The entire arrangement is only clever, and not exactly talented, and already shows the beginning denial of the wheel window, that in a sense only occurs as the dominant part of a great round arched window. We compare it with the corresponding one of the transept of Chalons, which in magnificent design and bold execution scarcely has its equal (Figs. 932, 932 a). Here the side arch remains as a pointed arch, and the entire area enclosed by it down to the floor of the triforium is filled by a window, whose form is dominated by the inserted wheel window in a decided way, although its diameter is less than the span of the side arch. Then there is that mentioned on p 407, the motive employed in the aisle for lowering the little columns of the longer window mullions to the floor of the triforium and executed in a manner, that two of the panels bordered by these little columns are added to the outer circle of the wheel window, whose pointed arches are placed at the heights

of the capitals of the rounds. The little columns thus strength-
en the triforium in these parts and here also determine the di-
eter of the wheel window. The space remaining between the whee
the top of the triforium and the columns mentioned, then inste
of being a system of mullions as in Amiens, is here filled by
quatrefoils adapted to the circle, and therefore filled toward
the middle by quatrefoils diminishing in size. The membering o
these latter is secondary, i.e., they lack the strengthening w
which the columns mentioned and the outer round of the wheel window corresponding to them afford, which latter therefore forms a projection before the quatrefoil only furnished with a plate and chamfer like simple window mullions. Accordingly the quatrefoils support the lower half of the circle, or rather stress it and present the yielding of the separate pieces in a centrifugal direction. The same system is executed outside, but only with the difference that those little columns end at the stone slabs covering the triforium and therefore are much shorter th in the interior. The windows of the triforium again correspond exactly tn the internal spans of the arches, and receive a particularly rich treatment by the crowning gables.

Windows with pointed arches in the gable.

On later works the wheel window is found to be supplanted by an ordinary pointed window, indeed adorned in the richest form by mullions and tracery, thus a characteristic arrangement for this place by such a one that can occur everywhere. Meanwhile examples of this kind are already found in Early Gothic works like S. Leger in Soissons (Fig. 935).

In later times men proceeded to proclaim the window in the gable, that is found in the richest manner in the cathedrals of Cologne and of Meaux, as characteristic of the German Gothi and forming the proper consequence of the system. Only so much of this is true, that the origin of most German works, at leas of the richer, falls in times in which even a certain exaggeration of verticalism was intentionally sought and that exaggerated consistency down to all details. The system of Gothic construction leads with entire necessity to a predominating vertic effect of the whole, which however in the simplest of the earlier works, as shown in Figs. 933 and 934 representing the transept of Notre Dame at Dijon, is already just as powerful as in the likewise great wheel window, indeed contained as the chief

object in the west end of the Strasburg minster, Or that of Cologne cathedral. But the assumption that this grand character of the whole is carried out in its details, and that all more neutral forms must be excluded applied with entire necessity to the removal of all circles included in tracery, and hence led to the forms of the English perpendicular style, in which certainly the round window was everywhere supplanted by the pointed window, but also the separate divisions of the tracery presented only proportional repetitions of the main form of the whole.

While in Cologne the side arch in the transverse aisle is also a window arch at the same time, and the triforium yet retains the simple form of an arcade balustrade, there is found at Meaux a more affected arrangement, where the proportion of height does not permit a similar development, whose system we represent in Fig. 931 from a hasty sketch. Here the width of the window divided in 8 parts and filled with rich tracery is about a third l less than the span of the side arch, and thereforeits ground l line is raised above that of the latter. The triforium is approximately of the same width and is then divided in 4 panals c crowned by gables, and each of these is again bisected by a middle mullion.

The passage above the triforium is also found inside, and like the triforium is furnished with a tracery balustrade. The height below the triforium corresponding to the side aisle, in which should be continued the window story of the latter, is then spanned in the full width of the transverse aisle by 3 divisions with pointed arches and crowned by gables on 4 pier bodies set diagonally and crowned by pinnacles, the gables being again divided in 4 panels by a system of large and small mullions, about the lower third of which is cut off by a horizontal member corresponding to the window moulding, in which however the same system of cullions extends to the floor, thus representing an arcade.

If we also compare this happily designed system to that of Chalons, there results a substantial difference characterizing the different style periods. Here is seen the endeavor to unite into a vertically acting group two stories separated horizontally from each other according to their nature, namely at Chalons the triforium with the upper and in Meaux twith the lower window story, or the blind arches replacing it. But in the first place

this purpose is attained in a structural way, for without those little columns extended downward and the arches turned on them, the graceful opening of the space under the rose window would not well be possible. On the contrary in Meaux all was obtained in a purely decorative way merely by the arrangement of pinnacles and gables, which contributed so little to strengthen the construction, that they could be almost entirely removed without injury.

If according to rule the triforium on the transept gable harmonizes with those of the nave, there are also exceptions to t this as in Rheims, where they have the same height but consist of only three spans. The same little dividing columns then bear the front ends of the stone blocks extending to the back wall, which form the springings of the likewise semicircular tunnel vaults.

Lower window story.

For the lower window story the breadth predominates iven more than for the upper one, that for the same heights resulting from the cross section of the whole will not even permit the arrangement of the wheel window, entirely aside from this, that such a repetition must weaken the effect. Thus there remains only the arrangement of several windows placed above each other, as they likewise result from that arrangement of plan represented in Fig. 929 with a separate cross vault. Thus is found in Chalons (Fig. 9_2) two windows divided in two parts and beside each other, in Rheims and S. Leger at Soissons (elevation in Fig. 935) are three single ones, but five such are in Notre Dame at Dijon. (Fig. 934).

The passages before the lower windows here appear in the same way from the construction, es in the choir plans (Fig. 927). In Fig. 930 let a b be the back wall of the triforium or the lower window wall, then according to the system of Chalons for supporting the triforium arcades, that are necessary with angle piers connected by arches with the middle pier c, which then to permit passage is penetrated or must be replaced by one or more detached little columns according to the division of the width of the arch. If then as in Rheims is also assumed for this passage the before described spanning of the triforium by three parallel tunnel vaults borne by these columns, then a harmony of the division of the window with the arcade thus formed would become a

necessity. But according to the usual arrangement whereby the little columns are only connected by arches and so form a wall, from which the floor slabs are laid to the window wall, can this agreement disappear. - very peculiar arrangement of the last k kind is found in Notre Dame at Dijon (Fig. 9_3). Here are arranged in the interior two little columns connected together and the angle piers by segmental arches and thus forming three divisions, yet behind which in the back wall are actually a very charming arrangement of five slender pointed windows, very horrible to fanatics for greater regularity.

Below the lower window story are then found portals, arranged as generally in the transepts, the doorways as in Chalons (Fig. 9_2). But if the heights resulting from the entire dimensions are not sufficient for the latter, they can also extend into the passage, which then as in the side aisles of the cathedral of Regensburg and of the Liebfrauen church at Treves extends o over stairs rising at both sides.

But greater portals must close at least a part of the windows by their arches and gables. Thus at Chalons of the windows visible in the division in question, only the upper circle in the tympanum of the arch is actually epened and glazed, the lower parts remaining only blind arches. This necessity has then led usually to a complete omission of the arrangement of windows a and the direct adoption of a system of blind arches as in the transepts of Amiens, an arrangement that corresponds to the structural conditions in like manner, in so far as thereby is obtained the required breadth for the design of the upper parts w without excessive wall surface, and with which those of the passage are just as well arranged.

Interior of the portals.

While in Chalons the doorways internally remain without decoration, the transepts of Amiens exhibit one kept indeed in moderate dimensions, but an inner portal with its gable extending into the series of blind arches over it. A greater development of the latter, which must be sought not at all in its greater projection inside, would then occupy the entire wall surface under the triforium and therefore exclude the lower window story. Such arrangements are chiefly found at the western portals. Thus in Rheims the space between the internally visible members of the jamb and the nearest rounds is animated by a system of blind

arches filled with figures in relief and arranged in several tiers over each other, which also extend above the enner arch under the floor of the triforium, and thus form an extremely rich enclosure. In the new transept at Cologne the wall surfaces between the doorway of the triforium are animated by the arrangement of a great number of small niches, which by the corbels placed in them and the canopies over them for places of figures appear characteristic. This is an arrangement which goes beyond the structural condition of economizing a mass, as expressed in the blind arches at Amiens and the internal portal arch of Rheims, and obtains a purely ornamental importance, but even therefore perhaps should have been repeated in the opposite transept, but in entirely but nearly similar form.

Organ gallery at the west.

Certain modifications may occur by the requirement of an organ gallery on the western wall.

The monumental solution of this problem, found inside the western gable of the cathadral at Soissons or the transept gable at Laon, can be termed an extension of the arrangement of the side aisle into the bay of the middle aisle. There came then between the western pair of piers one os two corresponding aisle piers, but each smaller pier stands according to the width of the span, from which extend to the western wall the ribs of the floor of the gallery, and a vault is turned to correspond to that of the side aisle. That with the arramgement of a middle pier the direction of the ribs is to be arranged with regard to an inner portal arch, and may make necessary an inserted triangular vault is self-evident. Meanwhile io thes case would be preferable the arrangement of the portal towers of the cathedral of Paris, where for the sufficiently strong middle pier separating the two doorways are turned the bisecting ribs of the octapartite vault of the lower.

From the entire arrangement of such an internal gallery it follows, that a richer triforium can no longer be employed from the aisle. Yet the design of the triforium itself, or that of a passage in the thickness of the wall beneath the west window may be of great use for access to the works of the organ. That the organ is to be limited in its height as far as possible and is to be so formed, that the existing west window remains uncovered, was already stated earlier. But this care may lead to pla-

placing the vaults in question lower than those of the side aisle.
For more on the combination of the western or a transept gable with the towers, see the Section treating the latter.

Simplified arrangement.

The before explained arrangement of the transepts is peculiar to great cathedrals and requires their dimensions. If these are wanting, then the heights are more limited, and there results the necessity of simplifying that system.

First is a reduction of the upper window story, no longer permitted by the arrangement of a rose window filling the width of the transept, or in general a great arrangement of windows dominating the entire surface of the wall in the elevation. Since the predominance of this window story is a condition of the unified effect of the entire system, then must the triforium be omitted on the gable wall of the transept, and the communication of the passage above the triforium on the longitudinal wall of the transept with the latter be made by stair towers at the angles of the transept, while the triforiums themselves are connected by a passage above the lower series of windows.

Such an arrangement is found in Notre Dame in Dijon (Figs. 933, 934),where the stair towers in kuestion are corbelled out directly below the lower passage, and therefore must evidently fisst satisfy the purpose mentioned above. The same simplified arrangement is found on the transept of S. Leger in Soissons ((Fig. 935), where the stair towers are still carried to the ground, just as on S. Martin in Laon.

All these arrangements are based on this, that the upper window on the transept gable fills the height taken by the window story and triforium in the aisle under consideration.

By the arrangement of a portal then, as mentioned above, also the lower window story is omitted. However the horixontal division of the aisle, and wherever possible, also the passage above the height of the side aisles must be carried across on the transept gable, in order to connect it with the whoel both naturally as esthetically tasteful. To moit this division and to fill the transept gable by a window extending down to the sill moulding of the side aisle, strictly taken, with the design of a clearstory as a transept gable constructed to bring into connection a system of aisles of equal height.

7. External Treatment of Gables.

Lower wall of the gable.

Up to the base of the roof there result the different developments of the gable front from what has been said in the cross section heretofore, according to the simpler or richer design thereof. Therefore we first turn to the examples given in Figs. 931, 932, 933.

Small towers or buttresses at the angles.

A means essential to an effective treatment, as the principles of construction already give, lies in a bold handling of the angles, in flanking the gable either by buttresses of increased importance or by small angle towers. Both arrangements then often coincide, for the outline of the building, either occurring connected together as in Fig. 934, or that on the buttresses are set two angle turrets at a certain division of the height, usually corresponding to the base of the roof, that extend above the apex of the gable.

The importance of this treatment of the angle must naturally increase with the opening of the gable wall by that form of window occupying the entire span, where the thrust of the arch loaded by the gable already creates a structural need for strengthening the width of the abutment. Conversely it is reduced for a closed treatment of the gable wall and is also reduced with a smaller width of window to the dimensions of the ordinary buttress, so that then are also wanting those angle turrets extending above the apex of the gable. Yet where the latter are found without the need of strengthening the abutment, as in Limburg and Wetzlar (Fig. 936), since their form in a sense is derived from the form of the plan, thus in the first place from the arrangement of narrow passages across the transept, on the latter from that of the internal angle pier (Figs. 854, 936 a), which permitted the use of this so extremely effective motive in respect to form. Other examples of an arrangement of the same with a smaller width of the window are shown by the cathedral of Meissen and that of Magdeburg.

Blind arches near the upper windows.

The effect of that design of window opening the full width of the gable wall, is so overpowering, that certain designs are explained thereby, which by a different construction approximate this effect by variously treated blind arcades. An example of

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The effect of that design of window opening the full width of the gable wall, is so overpowering, that certain designs are explained thereby, which by a different construction approximate this effect by variously treated blind arcades. An example of

this kind is shown by the north transept gable of the collegiate church of S. Quentin, on which the great blind pointed arch enclosing the wheel window is adjoined at each side by a smaller one filling the spaces near to the buttresses, which are separated from the great one only by the little columns supporting t the arched passage. Even more plainly is expressed the endeavor mentioned on the south transept gable of the collegiate church at Colmar, on which at each side of the pointed window in 6 divisions filling about 2/5 of the width of the gable, is a blind arch entirely separated from that, and spanned by closed trefoil arches and crowned by gables flanked by pinnacles.

Triangle of the gable.

Passage on the triangle of the gable.

What now concerns the form of the elevation of the triangle proper of the gable, the proportion of the latter to the lower wall portion, it stands in the most intimate connection with the varied arrangement of the edge of the roof or of the gutters along the eaves. If then the water at the long sides simply drops over the edge of the cornice, or if generally at the base of the roof no balustrade is found, there is also no need for arranging it before the gable, since it no longer has to form a communication. Therefore the plain wall of the gable triangle is opened in any manner or is entirely closed and stands above the face of the lower wall as in Figs. 934, 935.

Now compare the first Fig. with its section in Fig. 934 a, t then the entire thickness of the dividing arch remains up to t the window wall beneath the roof, without any appearance in the development of the elevation. Utilization of it is generally n near to a simpler form of cross section of the full thickness of the gable wall, and may first consist in the use of the triforium in the gable triangle.

Thus are found in the south transept gable of the collegiate church at Wetzlar (Fig. 936) a series of piers over the proper window wall, and above them in Fig. 934 is visible internal piers and the closed gable wall, from which are laid thick stone blocks to those piers, that afford important support for three pointed tunnel vaults turned from pier to pier, so that the latter cover the passage between piers and the gable wall. Other examples of the same kind, which however acquire greater richness by the little columns dividing the span of the arch are

shown by the transept gables of the cathedral at Limburg, and a particularly graceful arrangement of this passage of the west gable enclosed by great towers on the same work (Fig. 937). The same motive is then shown in a way more nearly allied to the gable of Wetzlar by the transept gables of the cathedrals at Meissen and Magdeburg and by S. Blasien in Mühlhausen. Here those widely spaced strong piers are replaced by a crowded arrangement of mullions without capitals, which again follow the direction of the gable and are connected by trefoil tunnel vaults, so that their springings extend to the back wall. There the higher mullions are joined with the back wall by stone blocks parallel to those spacings. Retaining the same arrangement, perhaps the mullions could be replaced by little columns with better effects, whose capitals form that connection.

If in the manner frequently exclained we now assume that the mullions or little columns are only connected by cross arches instead of tunnel vaults, there results the need of covering the passage by stone slabs, that are laid from the arcade wall thus formed to the solid gable wall. With an arrangement of the arches following the inclination of the gable, these slabs must be laid on each other with their tops forming a stairs leading up from both sides to the apex of the gable, that will later find a fuller explanation (See Gables).

Horizontal termination of the passage.

Meanwhile the parallelism of these arcades to the inclination of the gable is nowise a necessity. Instead of this can occur an equal height of the arcade horizontally, and the passage be either covered, or instead of the stairs can be formed a second uncovered connecting passage between the corner towers flanking the gable. Then the entire construction, i. e., the arcade wall may either receive less height with the connecting passage over it, so that the upper part of the triangle of the gable rises above it, or it may occupy the entire height of the gable and thus form a horizontal termination of the west front. the last is found on the west end of the collegiate church of Mantes ((Figs. 939, 939 b) and on the cathedral of Paris, on the latter indeed being developed from the peculiar construction, so that over the two western bays between the beams is found a terrace, while the gable proper is [illegible] towers, whose western sides are then connected by doubled arca-

arcades, that bear the connecting passage.

But we return to the ordinary arrangement, where the roof of the middle aisle extends between the towers, and thus the gable walls either extend up behind the arcade, or they retain their triangular form and then correspond to the front only by short columns set allording to the inclination of the gable which support the difference between the gable triangle and the rectangle formed in the elevation by the front arcade leveling the floor slabs of the upper connecting passage. An example of such an arrangement is shown by the west end of the collegiate church in Mantes (Fig. 939). We call attention here to this, that the front columns are connected with the back wall by large stone blocks, whose front ends form the capitals of the lower columns. On the west end of the cathedral in Laon is found then the peculiar arrangement,that the gable or rather the roof of the middle aisle apparently projects through the connecting passage between the corner towers, so that the entirely closed front wall only animated by blind arches of the latter appear as if placed on the gable triangle, as we have stated above for the rear wall.

Free passage before the gable. Round windows in the gable triangle.

Simpler becomes the entire arrangement by an uncovered gallery at the height of the base of the gable, whereby the gable triangle is entirely visible, and can be opened by windows at different heights. Certainly here is indicated the wheel or round window as soon as a richer treatment is concerned. Also the same which the transept of Notre Dame in Paris shows is very compatible with the arrangement of a great wheel window lighting the transept below, and even by the necessary smaller dimensions of the resulting simpler design is adapted to emphasize the size and magnificence of the lower one. The harmonious effect of the gable triangle can then be enhanced by the addition of three small and likewise round, trefoil or ordinary pointed windows in the three angles of the gable. The same purpose of a complete harmony of the opening with the form of the gable is further attained by three round windows set in a triangle, that approximate the effect of a trefoil. Such an arrangement is found on the north transept of the church of Gelnhausen, indeed at a different place below the gable in the circle of the side arch.

The design of such round windows is very compatible with that

of an arcade passage before the gable wall, indeed it is effective by the connection with the latter in a manner like the back wall of the triforium but is more effective. In Mantes (Fig. 989) the gable wall at each space of the arcade is opened by a little round window.

Decoration by figures in the gable.

If the arcade passage does not extend up to the height of the ridge, then a part of the gable triangle remains visible over it, and the latter can either be opened by a window or have a representation of a figure in the round under a canopy or be adorned by a relief. The last is found employed on the entire gable of S. Martin in Laon.

A very peculiar development is shown by the west gable of the church at Pforta. For here before the proper stepped gable of the church is corbelled out an arch occupying nearly the entire width, which terminates at top in a simple gable lying before the stepped gable, and thus forms a colossal canopy, beneath which is represented in the round the crucifix, with S. Martin, S. John and 4 angles beside them.

But the most beautiful and perhaps in this way unique example of such a filling of the gable is presented by the Liebfrauen church in Treves, whose gable does not occupy the entire breadth of the roof, so that under the gable triangle is inserted a rectangle. This entire area enclosed by an inclined cornice filled by leaves is then divided into three blind arches, which are s simple round arches. Before the middle one is placed a closed crucifix, while S. Maria andS. John stand in the side arches.

Pointed windows in the gable triangle.

As in the window stories of the west fronts, also in this triangle the wheel window is commonly replaced by a pointed window, indeed either being filled by great dividing mullions with tracery, or by several single windows placed beside each other. The latter may be of equal height, or increase toward the middle, so that the entire group approximates the inclination of the gable or is parallel to it. With uniform heights, above the window group may be found a second and again concentric opening.

Resolution of the gable into tracery gables or steps.

On later works the entire area of the gable is divided by piers with pinnacles into a number of spaces usually divided by pilasters and connected by arches, that again end in gables as

top, which extend between these pilasters.

By such an arrangement is found as the earliest and best example on the church of S. Elisabeth in Marburg, the triangular f form indeed passes into the stepped, and is but partly visible through the openings of the arcades. Thus eo Marburg the general arrangement still has great freedom, far removed from the almost rigid effect of the later development with pinnacles.

For the width of the gable is divided in three pointed blind arches by mullions and tracery, the middle one far exceeding the others and occupied by a rectangular doorway almost to the base of the arch, from whose lintel are corbelled out the pilasters dividing the upper part of the blind arches. At about the same height are corbelled from the intermediate and wall piers 4 pinnacles in the form of Equilateral triangles, between which gables span the side recesses, whose openings end at the same height as those of the finials. Directly over the latter are corbelled out before the intermediate piers again two entirely similar pinnacles, betwheen which a gable spans the middle recess. At the height of the corbelling of the last mentioned pinnacle are then found a horizontal cornice over the side gables, on a which are then set 3 little turrets, the middle one of them standing over the crowning gable, and between which the horizontal line of the cornice is animated by two half battlements adjoining the turrets and a giddle stepped one.

If this gable is in the most beautiful harmony with the west window beneath, that belongs to about the close of the 13 th or the beginning of the 14 th centuries, like the Elisabeth church in particular, somewhat forestalls the contemporary development of other works, and it must be difficult to find a suitable termination for the latter, then the other examples of this kind in Nuremburg, Prague, etc., are merely variations of the same theme, that first differ from the Marburg example by more subdivision and then also with the gables of the separate steps continue horizontally above the surface of the gable between the separate pilasters, and divide them into several stories.

If on the gables of the transepts and of the west end the passage beneath the windows of the window story is arranged the same as on the longer side after the manner of Fig. 913, then for the upper one at the height of the base of the roof is situ-

either isolated, or the area is lost for the passage connecting the roof galleries. This evin the case on the longitudinal walls, yet here is easily obtained the necessary area to receive the roof beams bu an arch turned inside the face of the wall above the springing of the compartment and resting on the thickness of the vault. This becomes more difficult to execute on the t transepts on account of a length of bay far exceeding its width, and thus it is nearer to avoid that loss of area, so that the upper passage comes to lie exactly over the lower one, and is supported by any construction resting on the latter. Such an example from the Strasburg minster has already been mentioned on p. 351. Other arrangements would consist of an arcade set on t the edge of the lower passage or of an arch turned between the buttresses. If we conceive the latter applied on the transepts of Chalons, (Fig. 9 .), which in reality terminate with a hip roof, then would the arch concerned be about concentric with the upper pointed arch. In contrast to the before mentioned arrangement the gallery on the south transept gable at Colmar would be simply supported by strongly projecting corbels.

To all the richer forms mentioned we again compare the very simple gables of Notre Dame and of S. Leger at Soissons, as proof that with entirely consestent execution of the whole, and the almost necessarily resulting good proportions that richer ornament was not at all required to produce a happy effect.

Inclination of roof and gable.

But of great importance is the proportion of the inclination of the clearstory roof. If it is not to be denied,, that the G Gothic art of the last period was especially pleased by the arrangement of very steep roofs, and likewise conversely was so fixed, that this nowise excludes the design of flatter roofs, as such are presented by the frequently mentioned terraces, and usually low roofs of the side aisles, and also the roofs of secular buildings in southern countries, and even the houses of Swiss and Tyrolese peasants, still in general the preference is for steeper roofs particularly for covering church buildings. As limits for the inclination of clearstory roofs may be regarded the proportions of 5/7 to 1/4. But also an increase in parts carried higher, those of the clearstory roof above that of the side aisles, of the tower roof above the former results almost necessarily from the verticalism peculiar to Gothic art. For

example let Fig. 938 a be the outline of a choir with clearstory and a tower at one side, which is constructed according to the principle just mentioned and thus is easily attained its stately height, while in Fig. 938 that formed with parallel inclination is lamentably inferior; yet in reality this contrast is more decided according to the laws of perspective. Also to the horizontal termination is peculiar an equal division, particularly if certain higher parts of it exist, while the flatter inclinations of the roofs, especially in great groups of structures, produce the effect of stumpy indecision, and also require with a simpler design certain decorative or structural additions, in order to conquer this, as to be sought in the great acroterias of the Greeks and the wide projections of the roofs of those mountain houses, to which we have just referred.

Further reasons resulting from the propor purpose of the roof and of the nature of the materials to be employed, particularly in our climates, we leave entirely aside as generally known, and we state only that particularly in the restoration of mediaeval works the preservation of the original inclination of the roof is the more important, when it seems to oppose too much the modern esthetic feeling at least in many places, so that in the p present time many roofs of old churches require earnest help, for the danger is near, to see them replaced by designs of roofs suited to the so-called spirit of the times.

But may all capable of such a beginning previously subject t those examples to a more careful examination, in which the mentioned change of the roofs is shown completed, and the effectiveness of the outline thereby obtained be compared with that, which the work produced in its original form as in Merian's Topography, the trivial proposed form with the bold decidedness of the old; we believe that it would be rejected. (Illegible).

VI. SUBDIVISION AND CROWNING OF THE WALL.

1. Subdivision in General.

The continued subdivision of every kind in cornices, jambs, enclosures, piers, etc., is composed of the following elements.

1. Plane surfaces (slabs, chamfers, bevels, washes).
2. Projecting curved surfaces (rounds, scrolls).
3. Sunken curved surfaces (hollows).

Separate mouldings.

Each of these surfaces may already by itself form a moulding, and thus a simple round may serve as a neck moulding of a capital, and a simple chamfer, a rounding or cove, as a decoration of an angle. But usually several surfaces are joined together in a moulding, either forming a gradual transition or a simple combination side by side.

Compound single mouldings with gradual transition arise, when plane or curved surfaces so succeed each other, that in the cross section the separate parts of the profile adjoin each other without breaks (with a common tangent), and there are formed in this way transitions from the cove to the plane (Fig. 940), from a round to a plane (Fig. 941), from a cove to a round (Fig. 942). Transitions from a curve to a larger or smaller one in the same direction (Fig. 943) can scarcely be counted among compound mouldings, when they do not represent in the cross section a succession of circular arcs (Fig. 943), but a constant change in curvature (ellipse, parabola, spiral, etc.); mouldinms of the last kind are usually drawn freehand, and therefore cannot be represented or named mathematically.

Compound single mouldings with abrupt transitions occur, if flat or curved surfaces with expressed angles so adjoin each other, that they always produce the impression of a single member. To these belong the compound bowtell (Figs. 944, 945), intersections of pointed rounds (Fig. 946), even mouldings with divisions like a bundle of rounds (Fig. 947) or a fluted round can be included here. These forms already lead to placing mouldings side by side, the proper members.

Combined mouldings.

Rich members are combinations of single mouldings of more or less value connected together, or by small intermediate small mouldings. Hence the projecting mouldings are generally termed principal, and sunken ones are intermediate.

According to the succession and direction of the connections, the predominance of one or another moulding, the course of the lines in each separate moulding gives an inexhaustible abundance of expressions of form, which in every style speak a particular language without the addition of other ornament. The stage of the culture of the people, its entire mode of feeling, surrounding nature, climate, existing structural materials, and many other effective circumstances contribute their influences in the development of every architectural member. How greatly the same profile of a member may change its expression may be represented by the comparison of a crowning member (Figs. 948 a, b,c) and a base member (Figs. 949 a, b, c) in antique, Romanesque and Gothic conceptions.

Already in the separate divisions of Grecian and Roman art was completed a transformation of the members, which even more decidedly continued in Byzantine and Early Christian art, so that the so-called Romanesque style exhibits a new stamp.

Romanesque members.

Romanesque members avoid soft transitions, but place the separate mouldings directly or by mean and small connecting mouldings without expression beside each other. The curves are near circular arcs, the expression of the mouldings is plain and modest, rounds and coves exhibit a moderate extent of one fourth to one half the circle.

Gothic members.

To Gothic members are peculiar great life and heightened expression. Transitions are according to needs, sometimes soft and sometimes very decided, rounds and hollows predominate, and where bold effects are concerned the semicircle is important, but on the other hand also occur very delicate curves. The simple circular arc becomes rarer, freehand curves dominate, that show constantly changing curves like the style of spiral lines, they are found beautifully expressed on the lower torus of the base, the concave line of the capital, the cavetto of the main cornice, and they are very particularly suited to exhibit the noble inventions of the master. The effect in place is always studied w with great devotion, it leads frequently to a course of the lines, whose appearance is almost foreign to geometrical drawing, while in reality it exerts a very particular charm.

In the members of the external cornice occurs the necessity

for safely conducting away the falling water, expressing in this its rights, of washes thereby required assuming a particular expression and iyfluencing farther the form of the cornice. Similar washes also occur at many places in the interior, where it is necessary to avoid concealing the wash from a low position of the observer.

Diversity in the development of Gothic mouldings is almost unlimited, it goes so far that even mouldings corresponding to e each other in the same building always exhibit new changes according to the relation of the different parts, the height of t their location, the standpoint of the observer, the lighting, etc. Otherwise their generally strong variations not only accord with the art divisions of the different times, but also according to the lacally different activities in art. In the last respect is expressed very particularly the material at command in the vicinity. Entirely aside from the separate forms of brick and wood construction, cut stone shows very great peculiarities according to its softness, cleavage, color, dimensions of blocks, its grain and polish, that find their reflection in working and in the appearance of members. The middle ages never did violence to building materials in its best epochs, but utilized and treated them as they deserved..

Formation od mouldings in brick construction.

Brick architecture is far different from cut stone architecture in its innate nature and external expression; in the middle ages it ever took its even course, so that one can speak of a separate brick style. Its differences lead in part to the peculiarities of artificial stone, but rather refer to its mode of preparation. Forming and burning supply only small pieces of uniform size, that for the great mass of masonry receive a simple prismatic form. With these ordinary wall bricks are even constructed simple cornices peculiar to brickwork; yet when members require moulded bricks, whose kinds are limited as much as possible in the same structure, when the same brick finds use so far as may be in different places. The moulded brick as a rule is restricted to the dimensions of the ordinary brick, it is made in special moulds or prepared from the usual bricks by cutting off the superfluous clay, and sharp reentrant angles a are to be avoided. Developed forms like moulded angles and yet more plant and figure ornamentation must be shaped by special

moulds or by freehand modeling.

There prevails in brick architecture in a certain sense the industrial character over the artistic and fanciful, that is peculiar to stone architecture, but sound logic expressed in all its members as in the arrangement of the whole, causes it to be scarcely inferior to that in respect to style.

While until in the 13 th century a tendency toward stone forms is made known, thereafter the members of supports, arches, jambs and cornices ever become more independent. Among others the main cornices do not adopt the great cavettos of stone structures, they are animated by arched friezes or arrangements of moulded allied to these, by continuous terra cotta plaques or recessed panels of plaster. Drip mouldings or undercuts are restricted to the height of a course set on edge or a roll (Figs. 950, 950 a) and do not fail at the projecting edge of the roof. A drip could even be formed by the lower projection of a simple inclined brick as shown by the window sill of Fig. 951, where p is the covering brick course and a would be the lower piece of the window frame.

For a brick moulding to be effective, it must have a certain least dimension, in order to appear above the strong color of the wall, as well as the contrast of it with the white joints and the usually alternating glazed courses. Thus generally and aside from the technical execution, the size of the moulding depends on the material, its color and texture. Thus as we see on Grecian temples the fine grain and color of marble permitted more delicate members, than dark and coarse grained sandstone or limestone, hence it is more possible to design members in the mass more gracefully, when the different parts are separated by different coloring, as again on the Grecian temple and on mediaeval woodwork. But every puerile and weak member in brick is ineffective in a high degree, as so many modern brick buildings prove.

An exception in regard to the size of mouldings is formed by the ornamental bands occurring on the richer works, as on the architrave of the Holstein gate at Lübeck, which consists of large peculiarly shaped and glazed plaques forming rich tracery or foliage ornaments, whose lines then show sharp members, tha- neither great nor deep. Since here the operation of burning demands a great difference in the thickness of plaques, as would

have been unavoidable for deep mouldings, then were rather less necessary, rince these ornamental bands already by the continuity of their color are separated from the otherwise colored wall surface in coursed patterns, thus their members are in relation to the size of the plakues rather than to the whole.

But this combination of the members by color is thereby obtained on most north German brick monuments also on window and doorway architraves, since these are set with glazed bricks, w which then contrast with the red or striped wall color. It is understood that the use of glazed bricks at angles and jambs was first allowed by the need of giving a protecting coating to the most exposed parts. Figs. 9,3 and 959 exhibit different moulded bricks chiefly taken from works in Lübeck, that either are derived from the chamfer, like those in Figs. 956, 957, 959 a, b, c, or from the round shown in Fig. 952. The peculiar form of Fig. 954 is generally executed in elevation in the way that the separate lines a, b, c, are spirally cut in the thickness of the brick, so that a comes at b on the bottom surface, etc., as Fig. 954 a shows. Care is to be taken for such mouldings, t that the extreme edge at d in Figs. 9,4 and 955 are not too weak but remain at least 3 cm.

For each combination of the separate moulded bricks in a richer member the wall bond is then determinative, which allows the form of the entire moulding to appear with a certain number of rectangular angles of the width of bricks or half lengths as m most natural, like a d b c in Fig. 959. This ground form may t then receive the simplest modifications, if the separate moulded bricks are separated in places by flat surfaces set between them of about half a brick wide, so that the series of bricks result as a e c, a e f or d e c etc.

All separate mouldings represented hitherto are symmetrical with the diagonal, so that these bricks serve as stretchers or headers. More varied forms are obtained when this symmetrical shape of moulded bricks is dropped, as shown by Fig. 958. But the shape of the separate bricks so far depends on the bond, that the centre of the hollow lies about in the prolongation of the end joint, so that the end joints pass at right angles through the moulding. Fig. 960 represents the bond of such a jamb, and shows that to execute the same, the length of the bricks must be to the unchanged widths as 3 : 2, so as to req-

require the so-called three-quarter bats.

But this length no longer suffices for a jamb profile formed as in Fig. 958, since then as the line b c shows, the strength of the brick at c remains much too small. Therefore to make the bond possible in the same condition it is necessary to transfer the joint b c to d e, so that the length of the brick is to the width as 5 : 2.

A rich selection of such brick jambs is contained in the works of Essenwein, Adler, etc.

Mouldings of woodwork.

By the lengths of the timbers supplied by nature, by the direction of the fibres, a difference in strength connected with them crosswise and lengthwise, further by the sensible hygroscopic peculiarities are the ways indicated for treating woodwork. Structural members were so closely adapted to the peculiarities of the material and the purpose of the object in the middle ages as in no other division of art. Likewise the purely ornamental members have their character expressed in wood construction. Here and there indeed a certain echo of stonework is not to be denied, but then there is always a transformation corresponding to the purpose as to the material in like manner.

But an objection to this relation of forms for mediaeval art is unfounded, at least for those which cannot find words enough to wonder at Grecian art. If then one still in modern times (in spite of Semper, Durm and others) cannot exclude the duration of the assumption that many, and just the more essential parts of the Doric order are merely memories of a prehistoric wooden architecture, that men endeavored to transfer the forms peculiar to the lighter and tractable material to the heavier and more stubborn stone, even such forms as were meaningless for the latter construction, like drops and mutules. But it was far nearer then for mediaeval workmen permeated, as they must have been, by the nobility of Gothic art first belonging to stonework, that they strove to make a part of the fullness and magnificence of it peculiar to their own handiwork. They indeed transferred just in a concise sense the forms of the unyielding to the more yielding, material, and indeed not blindly imitated but transformed t

This change from stone to wooden forms resulted from natural conditions. At first in the various works in wood it did not com to produce monumental effects, but to serve the purposes of th

lives of citizens, or in works rather belonging to furniture to obtain a certain convenience for use. Thus works of wooden architecture are almost entirely found near the eye, thus permitting a greater refinement of grace in the forms, to whose aid almost always came painting, which could occur only in a far more limited way on stone architecture. But the material itself aids this greater detailing, so far as it allows sharper angles, use of thinner masses, conditions of the connection of different parts, the requirements of stability reached by lighter and simpler means, and thus favored a freer and more ornate treatment of the whole. As in stone construction all undercut members in the interior are more or less lacking a technical purpose, and where they occur only the bold effect is retained, so in the woodwork vanish all requirements to be necessary, since even in external architecture the desired protection is of brief duration because of the transitory nature of wood when exposed to dampness. Therefore where on woodwork are found forms, that seem allied to the cornices and mouldings of stone construction, they serve there only as crowning and ornamental bands and thus a m merely decorative purpose. Hence in but few cases are they wrought in the solid mass of the wood, but far more commonly are n nailed on. Accordingly from the almost typical stone profile in Fig. 9 1 are formed the wood profiles in Figs. 962 and 963. If these are nailed on, the deepest part of them must not be on the face of the wall (as in Fig. 961), thus here falling on the line a b, but at c must remain sufficient wood that the nail holds the strip.

The sharper and thinner form of the edges and of the projecting parts further makes undercutting for the effect dispensable. But in certain cases it makes more difficult the work in quite a superfluous way. For example where such an ornamental band forms an angle at the edge of a frame, it is returned on itself (Fig. 964), the joint is not mitred according to the term, and modern practice is given by the thin line a b in Fig. 964 a, but is cut rectangular according to c b in Fig. 964 a. The first position of the joint will exhibit that ugly separation of two parts (c a b and d a b), that is so unpleasing in woodwork by the least drying of the wood. If then no intersections are found in the moulding of the crowning band, then each piece can be a stuck and then the moulding be coped for the distance a c at one

angle in Fig. 964. But if the cavetto is undercut the piece e f in Fig. 964 cut out of the fillet and must then be glued on again, if the angles op the band were merely stuck beforehand, hence producing an otherwise superfluous difficulty in the work.

Every sharply cut edge, that is so easily produced in working wood, is quite objectionable at all places usually exposed to human contact, since on the one hand the contact is unpleasant, and on the other it is easily lost thereby. Therefore on all such parts like architraves of doors and windows, framing and panels, etc., occur members for removing the sjuare angle are to be considered, such as chamfers. Their forms mostly suffer important modifications as a rule by the small thickness of such frames, that makes it desirable to increase the proportion of the width of the member to its depth. Accordingly the forms of Figs. 965 and 965 a become almost typical, by which are then also found other combinations, such as shown in Figs. 966 and 966 a. In a similar way mouldings are placed flat beside each other on wooden verticals, in order to form a slight projection of the upper and lower parts (Fig. 967). for more on this see p. 233.

More boldly shaped mouldings are usually found on ends of beams, that bear the projections of upper stories. As a rule these approach the rectangular form (like Fig. 968), since then generally the shape of the profile must be such, that the strength of the loaded end of the beam is reduced no more than safety permits. Examples of thes kind are shown by Figs. 969, 970.

The members of the sill lying on the ends of the beams, that become square at their bearing on the latter, also mostly correspond to mouldings suited for stone. Here may again occur undercutting, which will indeed even be useful so far as they prevent water from running down on the filling boards. But generally these are not moulded but retain the rectangular cross section like the antique architrave, and only their front side is covered by a surface ornament of tracery or foliage. More rarely are also mouldings nailed on outside, like railings of balustrades, whose forms may be about as Fig. 963, or better be a simplification of these. Purely ornamental are then the mouldings sometimes stuck on verticals and rails, that remain entirely in the plane and thus form no projection, being made with the steel in the wood as a substitute for a mouldinm in actual relief. S

Such a form is shown in Fig. 971.

Mouldings in metal.

While cast metal allows the greatest freedom, so that it lends itself to the representation of almost all forms that can be executed in other materials, wrought metal and especially forged iron draws the limits more closely. Mouldings, such as occur in stone and wood, almost wholly disappear in wrought iron, and men labored to replace the decorative effect by other forms more s suited to the nature of the material, or the lines forming the edges of the moulding were given, which in a drawing received only slight sinkings. Most commonly are found members on those iron parts that seem imitated from the buttresses of stonework, and therefore bear the same mouldings as those. For example such posts are found in iron grilles that enclose tabernacles, fountains, etc., or even form closures of choirs. The bases of these posts as a rule are then very simple, only having a chamfer or the moulding given in Fig. 972, on the contrary the cap is sharply cut with a thin border, formed about as in Fig. 973. The latter form is also sometimes assumed by continuous rails, as on the beautiful grilles of Magdeburg cathedral, on whose posts are also found more complex forms (Fig. 974).

On the imperforate tracery sometimes found is usually made a member of it in this way, that two thin hammered perforated bars are placed on each other, the lower projecting beyond the upper, so that Fig. 975 forms a cross section of a bar of the tracery.

Richer mouldings are found on bronze works, by which men in the middle ages usually strove to excel the magnificence of s stone architecture. Examples of this kind are presented by the bronze baptismal fonts of Würzburg, Münden, Einbeck and Lübeck, the lead fountain at Brunswick, and the extremely rich tabernacle of the church S. Maria at Lübeck. On all these works is found cast metal combined with forged work, as shown by the inscription on the latter. But by this procedure it was possible to attain the freedom of separate forms and the gracefulness of the moulding, which these works possess above similar modern works, especially those of highly prized cast iron. Fig. 976 shows the rail and base of the lower balustrade of that tabernacle, and Fig. 977 is the base of an upper pier (Note).

Note. See the Gothic Musterbuch of V. Statz and G. Ungewitter.

In the later periods of Gothic art, men sometimes toiled to

transfer also to stonework this delicacy and refinement of metalwork, when they made the hollows wider, projecting mouldings thinner and replaced rounds by angular mouldings. The greatest excesses in this respect are found in the French works in Late Gothic. As an example with all this thinness yet with a very effective cornice member from the palace of justice in Rouen may serve Fig. 978.

Still more graceful than the bronze works are those executed in noble metals, even if here the necessary handling opposed all sharp angular forms. But the genius in the mediaeval work which compares with modern, about as a sketch executed by a sure hand to a careful geometrical drawing, they also knew how to obtain in this case. Thus is found on the most graceful mouldings of this period, as for example that given in Fig. 979 from a monstrance in Hildesheim, yet avoiding all injurious sharpness.

Preparation and execution of the members.

Preparation of the mouldings.

It lies outside the scope of these pages to follow the manual execution of mouldings into their details according to materials.

In stone it is done according to the profile laid on the dressed plane surface, that for vertical mouldings corresponds to the bed joint, or for horizontal ones to the end joint. Execution is done with the template, which then after the moulding is cut must pass along the cut out space.

For bricks it is made by a mould in which the unburnt brick is pressed, or with a plane that cuts out the sinkings.

In wood it is effected by the plane that corresponds to the template, and where this does not suffice or is inconvenient, by chisels and gouges of different shapes, which are also employed as aids to the plane.

In cast metal it occurs with the pattern, and only in forging with freehand chiseling; in brief on all these works, only excepting the last, in the same manner in which the elevation is made from the plan or elevation in drawing.

Where a moulding extends around a corner, the line formed by this is executed by cutting at the same time, for wood sometimes by Mitring. In the same manner are found in practice the lines of all penetrations, both of the same as of different mouldings.

Projection of members.

In the earlier original sketches preserved to us are not found

such projectinss. Men in a sense drew as they worked, just as writing was formed from speech. Every projection on an inclined surface was avoided, and as on the original sketches of the Cologne towers, the architecture on the inclined octagonal sides was drawn exactly as if vertical, so that then on account of the defective width of the former, they were represented as cut off. Only occasionally were men assisted by an entirely conventional perspective. Yet at present it is no more expedient to employ such an artless mode of representation, we are already by custom so bound to a strict execution of projection, although this has little value in practice for oblique surfaces, since only in heights is given the actual measures. From the danger of repeating something long known, we shall explain the graphical representation of the intersection of members in certain frequently cases reduced to the simplest forms.

Examples of execution.

1. A moulding (a in Fig. 980) extends horizontally around a square corner. In the elevation the correct profile is shown at the angle b, where the intersections are not visible, yet on account of clearness they are indicated by dotted lines. But in the projection on a plane inclined at 45° is then shown the actual line of intersection of the moulding over the ground line c d in Fig. 980 a. This line must also appear if the body on which the moulding exists is placed like a square set diagonally. To draw it, the points c e f g d are projected perpendicular to the base line c d above the line h_1 y_1, above which will be represented the profile sought . On these lines from h i are laid off the heights of the points determining the profile, which are lettered the same at a (in Fig. 980), so that also the heights of the points e′f′l′g′a′from h i are equal to those of the points e f l g d from c k; thus the main points of the profile are found, that can be drawn so far as composed of straight lines. For determining the curves more points must still be found, at least m in a determining the lowest depth. The height of the latter from the line c n is therefore laid off from o to p, and the line p p is then drawn to c d, and from there the point p above h i, laying off the height of the point m from c k on the last line from h i, finding the point m′. In the same way are other points to be found from an accurate determination.

2. A moulding extends horizontally around an obtuse-angled c

corner (Figs. 981, 981 a). The relation of the points b c d e f to the corresponding points of the profile drawn in elevation is given by the similarity of the letters, so that the distances of the lines on the plan from b b′ are equal to those of the points of the profile from b h.

The points of intersection of these lines with the line b′f′ bisecting the angle are drawn upward in the elevation with the heights of the lines above, etc., so that the determining points of the line b′f′ are obtained. For a more accurate determination of the curves one proceeds as indicated in Fig. 980 and shown here by the dotted lines g g′ and q q′. But it is at least necessary to find those points which form the greatest heights and depths of the profile, like the point m in Fig. 980 and here the point g, so that if the line of the hollow or round is struck with compasses, the point of intersection of these with the horizontal and vertical radii, or if the intersection is not g given, the intersections of the profile with the line through the lowest point od the overhanging edge of the profile, i.e., the point i.

3. A moulding or a body with a simple ground form intersects an oblique plane like a wash (Figs. 982, 982 a, b). In this case the position of each desired point of the plan in the elevation is obtained in the following manner.

There is drawn from the plan, as from the point e, a perpendicular in the elevation (Fig. 982 a), laying off thereon the distance of this point from the edge of the wash in the section, thus the length f e in plan in the section of the wash (Fig 982 b) from cW and e′, erecting a fperpendicular at e′, and from the intersection of the latter with the line of the wash is drawn a horizontal, that cuts the vertical first drawn from c in plan, thereby determining the position of the point e″ in elevation. In the same way are found all others, as indicated by the similarity of the letters and the dotted lines. It is now only to be noted, that the distances of the points sought from the edge of the wash must always be taken in the half of the latter inclined at an angle of 45° to the plane of projection, and always in the direction perpendicular to the wash, so that also to find the position of the point p, the length p j must be laid off in the section from c′ to p′. The section of the wash is drawn twice in Fig. 982 b, so as not to mix the aiding lines.

4. - pier of polygonal section stands on a wash of a different polygonal form, i.e., a prism intersects a pyramid (Figs. 983, 983 a). In Fig. 983 a b c d gives the plan of the pier and e f g is that of the base, from which the wash rises.

First the angle points of both polygons are brought into the elevation, thus those of the base below and those of the pier above the line h h indicating the edge of the wash; then draw horizontally the line i, whose distance from h indicates the height of the wash, then upward through the points a k d, that denote the middles of the octagonal sides of the pier, so that the intersections of this line l l give the points of intersection of the wash with the sides of the octagon, and the edges l l′ are determined. Then draw from b in the plan a line parallel to e f to the line e a, and erect a vertical on the elevation from the intersection m, which cuts the line l l′ in n, and then a horizontal from n, the intersections of the latter with the edges of the octagonal pier are the points at which these edges rest on the wash. Connecting these with the points l already found completes the construction.

The same transition from one ground form to another may also be made in the manner given in Fig. 983 b, and thus according to any ground form. The graphical representation is similar in all cases.

5. Two differently shaped members, one of which is horizontal and the other vertical intersect each other. Such cases occur when the members of a doorway jamb stop on a moulded base, or if in a larger blind arch is a doorway covered by a straight l lintel, so that the members of the lintel intersect the members of the jamb of the arch, or when in an ordinary window with a stone cross, the horizontal transom bar instead of having the section of the muntin is formed with an ordinary drip moulding, etc. The first of the cases mentioned will suffice to explain the method.

Let Fig. 984 a be the plan of the members of the jamb, Fig. 984 b be the profile of the base, which in Fig. 984 a extends around the obtuse corner. It is first to draw the lines formed by both profiles in plan and elevation, and thus to select those points that determine the lines of intersection. Such points are those in which the edges or bordering lines of the separate members that strike the profile of the base, on in which the edges

or bordering lines of the base cut the profile of the jamb, or with recurved members, those in which the curves intersect.

Points of the first kind are k d l h in Fig. 984 a; points of the second kind being c m i b. To these are added those required for more exact determination of the curves, like f g in Fig. 984 a. To determine the point d, draw a d in the section in Fig. 984 b from a′ to d′, erect at d′ a perpendicular, and through the point where this line cuts the line of the profile of the base, draw a horizontal in the elevation at the same height (Fig. 984), and then the intersection of this also with the horizontal in Fig. 984 designated by d′, with the vertical through the point g in the plan will be the point sought.

Likewise to determine the point h, whose rectangular distance from the line a a in plan, in the section from a′ to h′ reaches in h′ a vertical that cuts the profile of the base three times. These intersections are drawn in the elevation, and thus the intersections of the last lines with the verticals through h are the required points h′, h′, h′ in Fig. 984. The point i or a c corresponding one results in the elevation from the intarsection of the edge line concerned of the profile of the base with the perpendicular drawn through i in Fig. 984 a according to Fig. 984. But since the round in the profile of the base has received greater projection by horizontal additions, then the lines 6 and 7 in the elevation are not identical with the line 1 in the plan, but the plan line corresponding to the first is set back farther, indeed so that this distance from the plan line a a is determined by the distance of the centre x of the round concerned in the section from the line a′a′. Therefore this distance is laid off in the plan, and accordingly there is drawn the dotted line 10, which strikes the profile of the jamb in o o o, these points are drawn in the elevation, and thus the intersections of these lines with the border lines of the round give the points sought at o′o′, by which the beginnings of the curves are determined, in which the round intersects the separate parts of the profile of the jamb. To determine the extreme point of this curve, or the point m, draw from m a vertical to the elevation and from the centre x of the round a horizontal across to it, so that the intersection of both lines gives the point sought.

2. Cornices.

Principal cornices.

Romanesque main cornices.

In countries where Romanesque traditions remained active, the cornices of the Romanesque style sometimes showed a great mass of corbelled members, but in general the principal cornice as well as the belt cornices at this time had already assumed a s simple and clear expression. There predominates either the round or the cavetto (Figs. 985, 986), or the round and cove succeed each other in rhythmic sequence. The clearest and most express-ive succession of mouldings to be obtained in the last way, must be the combination of two rounds with a middle cove (Fig. 987), and it has also been employed in manifold variations.

It is preferred to term the last moulding an inverted Attic base. Although a course of development from the Attic to the mediaeval base may be followed, the assumption of inserting this member for a crowning one is somewhat strong, and as we think is also entirely unnecessary. If usually there was an en-deavor to place round and cove beside each other, which Romanes-que art has done in every possible sequence, it was so self ev-ident, that one must hit on this form, indeed on account of its near simplicity in the first line, that to explain its origin does not require the traditions of the Attic base at all, so t that at most a certain facility in its use could be derived th-erefrom.

Those simple mouldings as shown by Figs. 985 to 987 are not sufficiently important for prominent belts or main cornices, a even if ornamented, and therefore subordinate members are usual-ly added, that consist of continuous slabs or bands lying in t the surface of the wall, a frieze interrupted by small piers ((Rhenish works), and corbels (especially in Burgundy) or the a arched frieze employed on German works with such preference.

The manifold treatment of the Romanesque cornice transfers itself to Gothic, in the lower members particularly developed in brick Gothic, while the art of cut stone rather returns to the upper continuous members and especially to the cavetto be-neath filled with foliage in predominant places.

Gothic principal cornices.

Like every other cornice, the principal cornice must prevent water from running down the face of the wall beneath it. Already the under surfaces of the Greek cornice in reference to this technical requirement is either obliquely undercut, as in the

Doric order (Fig. 988) or has a water drip as in the Ionic (Fig. 989). But to Gothic art was it reserved to devise an art form and from the fulfilment of this purpose (Fig. 990). How much t this form depended on that purpose is shown by many works executed with a certain economy, on which the undercutting or drip formed by the projecting edge of the roof covering was superfluous for the cornice, and therefore the latter consisted of only band and chamfer or band and cavetto (Fig. 991). It then had o only the function to remove the fall of the water beyond the f face of the wall. But any richer treatment would be made uncertain by the shadows of the edge of the roof, unless it was removed from their reach by a vertical surface of sufficient height, t thereby resulted the band a in Fig. 990 as an essential part of all such forms of roof cornice in contrast to the design of pseudo antique or modern cornices, in which generally the very d delicate upper edge is not alone concealed by the margin of the roof, but even by an inclined gutter hanging before it (on account of removal of water), and all richness is made unrecognizable.

But by the vertical band a the undercut cavetto is then again moved so far downward, that the function of removing water indicated by its form can be actually fulfilled. The height of that band generally equals the projection of the cornice, thus being formed as in Fig. 992.

Cavetto with drip at edge.

The members have an endless variety (Figs. 990 to 999). The most common if not the earliest profile is shown by Fig. 992, especially the slope in which a cavetto is cut; on account of its clear and simple form it may first be mentioned. It is recommended by ease in execution, which depends on the fact, that the stonecutter has to dress the minimum surface possible, which is removed by mouldings to be wrought later. Thus the oblique surface a b is first cut, in the latter according to the size of the cavetto is made a rectangular, oblique or triangular sinking c d e or c f g e, and thus the remaining circular segments between the sides of the sinking and the line of the cavetto are removed. It is generally necessary in the design of every member to take into account the mode of execution, and to draw the profile in the same way as the stonecutter works. Thereby can be avoided most certainly the very difficult and least effective forms.

To establish a definite proportion of the chamfers a c and eb to the diameter of the cavetto is impossible. According to the nature of the stone the distance a c, that results from the thickness of the overhanging part, may increase or diminish. As the lower limit may be designated a width a h = 1/4 of the width a b. According to the material is arrangem the depth of the cavetto, and thus the choice of its centre. In no case must the cavetto extend behind the face of the wall, so that g lies behind the line b i, while this point may well lie in it. From the choice of the centre and of the radius of the cavetto also results the width of the lower chamfer e b as greater or smaller. A satisfactory proportion results if a c + e b = c e and a c is : cb abo about as 5 : 3. The edges formed by the intersection of the cavetto with the chamfer best retain the rectangular form, and any pointed form is only permissible so far as the strength and fine grain of the stone permits..

In case the point g falls in the surface of the wall, the lower part of the profile can be omitted and the cavetto pass into the vertical surface, therefore being cut in a lower stone. It may likewise rest by a horizontal cut k l on the face of the wall.

Further the transition can be made by a rounding oninstead of the chamfer b e, or by a round in richer forms, that projects from the curve of the cavetto (Fig. 992 a) or this may intersect that (Fig. 992 b). Thus also the lower chamfer can afteruards be undercut (Fig. 993), as any combination of the different methods indicated above may occur.

Varied profiles.

The upper edge may also receive a richer form, as by the addition of the two chamfers a n and o n (Fig. 992) or a chamfer and a cavetto. The chamfer a n is therefore particularly characteristic, since it typifies the indispensable water drip in all other cornices, and that as a special undercutting of the roof cornice separates the upper band from the mouldings. This simple cross section in Fig. 992 may form the outline or rough shape for the richer and nobler forms given in Figs. 993, 994, and 995. The latter are entirely taken from earlier works, and we have attempted to bring them into a geometrical scheme as indicated by the lines sketched in. Yet no very great value is to be placed on the latter, and they may serve rather merely to assist the beginner.

But a slavish adherence to any such network of lines must be injurious in any case, and they are to be used in determining only a few particular points, while the same connecting cavetto either is to be struck from a freely chosen point, or is to be drawn freehand. The last procedure doubtless preceded the geometrical determination, even when all arches were struck with the compasses from points determined by the scheme.

On the earlier works are sometimes found also the undercut outer edge separated from the member below it, so that the latter has to support the overhanging edge drip. An example is presented by the cornice of the west faced of the cathedral at Rheims (Fig. 1000).

On many profiles and particularly of Early Gothic, the undercutting is transferred from the upper edge of the band to the lower edge of the cut stone, so that there results the form shown in Fig. 996, which is distinguished by a particularly bold effect of shadows.

Richer main cornice.

Thus in Figs. 991 and 991 a the edge of the roof projects beyond the face of the wall by means of a cove, so that also the drip forming a cove is set back by a second moulding beneath it. In the simplest case the latter imitates the former at a smaller scale (Fig. 997)., or since the undercutting strictly taken is here superfluous, it receives a different form. These compound forms of cornices are especially indicated where they consist of two or more courses lying on each other, as also in Figs. 997, so that each course has its own profile. Yet sometimes the form of the profile is independent of the location of the joint and the latter intersects the entire member with only a care for the skilful form of the edge (Fig. 999). The latter best suits the rectangular form, leaving the pointed, as dependent on the resistance of the stone and on the weight of the ashlars lying on it.

In the richer forms of cornice the ashlar with the upper undercut cavetto is generally supported by one steeper and flatter, that is entirely or partly filled by leaves. These latter have on the earlier works an actual structural importance and serve to strengthen the upper margin, Figs. 1000 and a in Fig. 1001.

But still more essential becomes the function of this over-

overhanging part of the cornice if the upper ashlar forms a gutter to receive the water flowing down from the roofs. The border of this gutter tehen has a parapet on the more richly formed c cornice in order to make access easier. The arrangement of the gutter thus leads to widening the upper surface of the wall, and the load of the balustrade requires a strong support by the lower cavetto. The walk is then set back from the outer edge of t the upper part of the cornice, and this upper margin receives the form of a wash.

Instead of foliage, these cavettos are also sometimes filled by figures cut from the mass of the ashlar (Fig. 1002(, cornice beneath a gallery on the south tower of Strasburg minster.

Belt courses, parapets and hoods.

Besides the architectural problem to separate two parts of t the wall lying over each other, to crown the lower or serve as a support for the upper, there comes in question here mouldings, for which the problem is almost entirely to cause water to drip off. Either they have to allow a great amount of collected water to run off (like cornices beneath window parapets),or they have portions of the wall beneath them, or also to protect dangerous joints from falling water (for example hoods).

Formation of the edge drip.

Therefore these mouldings as a rule require a strongly shaped wash or a drip, since they may be lacking on main cornices with projecting margin of the roof; but to change such a roof cornice as shown by Figs. 992 to 999 into one of the preceding kind, is conversely from the profiles given under Figs. 1003 to 1007.Figs. 1003 to 1008 contain some transformations of the proportion of projection by the form of the upper edge. The most of these profiles show projections equal or approximately equal to the height, only those are exceptions to this proportion in which by the omission of the lowest member occurs a reduction of the height. This most easily results by extending the overhanging part a in Fig. 1000 downward, so that by the addition of a cove tangent to the face of this member results the form in Fig. 1003 and that of Fig. 1004 by retaining the compound member given in Fig. 1000. Both forms are taken from the west front of the church at Haina. This extension of the margin may further occur by addition of a round or of an entire or half ogee hollow to the charfer a b in Fig. 1005. If then in this case the centre of this

moulding be moved out above a b, it is next to form the upper wash in a flat curve tangent to the curve of the round, as also given in Fig. 1005.

The same result of an enlarged undercutting can be obtained by making the cavette a pointed arch, which usually occurs on churches in Mühlhausen; it is shown in Fig. 1006. But most decisively is this result attained, when the moulding is exclusively cut in the horizontal under surface of the arhlar, and only the front edge of the stone has a chamfer as other moulding.

Thus the proportion of the projection may also become predominant by a lesser inclination of the wash, as from a to c in Fig. 1005 or from b to c in Fig. 990. It then depends on the nature of the stone whether the upper edge b remains acute angled or is to be made a right angle by the changed direction of the wash. The best assistance in this case is afforded by the form of the upper moulding as a round or ogee moulding.

The preceding Figs. mostly show a wash inclined at 45°, so that they may be regarded as shaped from the ground form of the square set diagonally, and thus the latter may also be replaced by the equilateral as shown in Fig. 1008, whose construction is explained by the aiding lines given.

Inclination of the wash.

In the church style these flatter inclinations of the wash form an exception particularly belonging to the last period of Gothic. On the contrary in secular works in many cases, for an unusual depth of the window jamb, it may be preferable to reduce the height of the wash of the sill by a flatter inclination, and to continue this over the edge of the projection of the edge of the sill forming a drip. But since the woodwork of the window frame rests on the upper edge of the sill, and thereby is desirable a rapid removal of the water nearest this, either the line of the wash can make an abrupt bend there or be raised by a curve (b in Fig. 1009). Then the wash of the edge of the member may also retain the original steeper inclination and form a bend next the sill.

In the better periods of Gothic art occurs the converse case, that the inclination of the wash is steeper than the angle of 45°. These steeper inclinations were then either carried over the projection of the member, or form at the face of the wall an angle with the wash of the latter inclined at 45°. Particul-

Particularly commonly are found such forms on the offsets of the buttresses, where sometimes the wash inclined at 45° may seem too weak to transfer the load from above to the under and larger surface, but on the other hand made necessary the formation of this wash in two blocks, and hence the arrangement of a bed dividing them became necessary (a b in Fig. 1010). But with a less steep form the latter would have had too acute angles at a. On English works is sometimes found the joint made easier by fillets, chamfers or undercuttings, that break the surface of the wash and afford a right angle for the blocks. (Fig. 1010 a). The same steep wash is sometimes found on the sills of church windows and finished at the inside edge with a shallow channel (c in Fig. 1010), which prevents the water from dropping that runs down the inside surface of the window. On many smaller parts like crossflowers, the function of the wash is neglected, where the little moulding (a in Fig. 1011) with the horizontal surface is attached to the stem. But here the joint lies not above but below the moulding, and therefore the horizontal surface cannot be injurious. Since also as a rule even a complete wash would not be provided below, thus the wash found at a is rather to be regarded as a chamfer of the front edge.

Hoods.

As at first were mentioned the caps of parapets, then everything said applies likewise to the proper hood mouldings, that occur above reliefs, inscribed tablets, or even richer jamb mouldings. For such purposes are suited the profiles given in Figs. 1003 to 1008, as well as part of those given earlier.

Belt courses.

The same forms are also assumed by belt courses, which indicate the floors of buildings in several stories, but at the same time serve to keep dry the wall surfaces below them, as Figs. 1012, 1012 a show. For while in the rain driven under b strikes the entire height of the wall, in the latter are formed dry places under the belts c, d and e with the same inclination of the rain, which then facilitate the drying of the remainder of the wall. Particularly the water running down the wall from above will be thrown off by each belt. The driving of the dropping water back against the wall does not occur in a moderate wind on account of the larger drip.

By a steeper inclination of the wash these belts may become also caps of balustrades. On the belts which neither at the joint adjoin woodwork or another inferior material subject to easy injury, like the caps of balustrades of galleries, the wash ceases to be imperatively necessary, and in some cases may be replaced by a horizontal surface as in Fig. 1013. Also the undercut may be omitted (Fig. 1013 a).

Junction of a roof.

Frequently the problem of the belt is to protect the joint between two different materials, and it especially occurs where a roof joins the face of a wall, no matter in what direction. The usual practice of the mason has neglected in modern architecture this protection, and aside from lead flashings has sought to replace it by a slight projection of the part of the wall above the junction of the roof. In a far more perfect manner is this attained by a belt with drip inserted directly over the l line of joining, which thus in the simplest case has the same relation to the face of the wall as the moulding b in Fig. 1010 a to the wash beneath it. A very clearly treated example of this kind is found on the sacristy of the church of S. Martin in Cassel, where over the junction of the roof and a window with the face of the wall, the moulding rises in a gable line and ends in a crossflower at top.

Corbelled members, Handrails.

Corbels are already in part contained in the given profil . Thus these are to be counted with all those parts of cornices, that support channels or balustrades, thus the lower cavettos in Figs. 997, 998, 1000 to 1002. A corbelling in the proper sense is further formed by the parapet cornices on the north side aisle of the Strasburg minster (Fig. 1014), in so far as the upper face of the wall against which stand the jamb columns a , project beyond the lower and place the bases of these little columns even out over the extreme edge of the member.

For this last projection accordingly is not arranged a proper corbelling, but it supports alone by the combination of the stone of this base with one of the bonded cornice stones. Here is a corbelled profile of the projecting base of the columnis omitted, which was perhaps originally intended. The entire design has a great effect by its bold projection, but is still not exactly beautiful and indeed is only based on this, that since

every parapet wall without load needs no great thickness, the upper width of masonry necessary was to be obtained for a passage extending around before the windows in the interior, by this corbelling is to be placed in connection with one lying somewhat lower inside , and the blind arcade extending beneath the windows, whose columns stand before the internal corbelling.

On a larger scale are found such corbellings beneath bay windows, turrets or balconies, or even entire stories. They may then either start from the capital of a column or pier as on p pulpits, or from a point in the face of the wall. The most common of these arrangements expresses the corbelling out of the roof gutter, according as the floor of the bay window is coposed of one or more stone slabs, which then projects from the face of the window in the form of a moulded drip moulding (a in Fig. 1015), and lies on the mass of the projection. The latter is shaped in the simplest case as an inverted frustum of a pyramid (Fig. 1015). But its angle of inclination must be tolerably steep, so that the angles of the blocks may not become more acute than permitted by the resistance of the stone. More frequently the corbelling shows members placed on each other.

On the cathedral of Chartres little basins like pulpits project from the roof balustrade above the flying buttresses, whose corbelling starts from a pier capital indeed by the repetition of that given in Fig. 1000, consisting below of a cavetto decorated by leaves. By this results the form of Fig. 1016.

In the later Gothic has striven much to make the very frequently occurring corbellings with the greatest simplicity by a mere repetition of cavettos undercut or sometimes as on the bay window of a private house in Erfurt (Figs. 1017, 1018), sometimes with the richest combinations of mouldings, of which an example is shown in Fig. 1019. The separate members must always follow a simple or compound principal line, and the latter results most naturally by starting from the originally rectangular form of the separate ashlars.

As a member required by a special purpose the handrail of stairs is included here. The principal member must be a round filling the hand in a convenient way. For detached stone railings this purpose is attained as in Fig. 1020. Handrails in the face of the wall are cut in the bonded ashlars, and in certain cases do not project at all beyond the face of the wall, but are prod-

produced by coves sunk above and below (Fig. 1021). The end joints of the ashlars intersect the member at a right angle.

Members of the plinth.

Romanesque plinth.

In the Romanesque period, besides the wash always occurring at 45° or the flat cavetto replacing it (Figs. 1022, 1023) from the church at Moringen), there appear arrangements of hollows and rounds, that often correspond to the Attic base, but sometimes even exhibit a richer series of mouldings. A Romanesque profile occurring particularly often is the cavetto with a round beneath as in Fig. 1024 from the church at Weiprechtshausen and Fig. 1024 a from the monastery church at Loccum, and it is again found almost unchanged in many Early Gothic buildings, and elsewhere it also reappears in many simpler Gothic profiles (as in Figs. 1025, 1025 a) in earlier and later profiles from the church of S. Alexander at Einbeck.

Inclined planes or hollows.

In these members is clearly expressed the function of the plinth, it does not crown like the cornice or protect lower parts, but it has to carry the pressure of the upper mass of the wall to a broader base and to show the projection thus arising. Both functions are entirely fulfilled by the simple slope or wash, which therefore is almost always employed on simple buildings, and sometimes even on quite rich works on account of this special fitness, and thus the base on the Strasburg minster is a simple wash beneath a richly moulded cap represented in Fig. 10.4. The spreading of the upper pressure is yet clearer by the wash in form of a flat arc, Fig. 1023 and a in Fig. 1026, that receives the next addition of a wash or other member of its lower edge b or c (Fig. 1026).

Compound members.

To express the ashlars of which is formed the profile of the plinth, this hollow is commonly separated by a remainder of the wash e in Fig. 1026 from the face of the wall, into which the hollow d directly passes. The law position of this member however causes it to be chiefly visible in direct view, but on the other hand its nearness to the eye makes a more complex form desirable, that was sometimes found in a profile hindering the floww of water (Fig. 1027), where the arc a in a sense forms the channel surrounding the base of the building, in which rain-

rainwater stood until dried out. But since this lower part of the wall otherwise is in constant contact with the damp earth, and since further other channels and even water basins made of stone, then this standing of water just in this place can do no injury, except that the joints are washed out and the projecting front margin is removed in the course of time, a removal occurs of itself, and the profile in Fig. 1027 is changed into the indicated form. But how slowly this alteration proceed is partly shown by the profiles of plinths of this kind dating from the 14 th century, as in Nuremburg, Mühlhausen, etc., that have retained this raised margin. Yet this form appears in a sense to be a transfer of forms from the interior to the exterior, a and therefore must be avoided, since it serves no real purpose, and hence is better formed at first according to the changed shape of the edge indicated in Fig. 1027.

On more important works the profiles of plinths are formed of two courses, and then also consist of two profiles separated by a vertical band. The height of this band is then decisive for the character of the whole. Examples of this kind are shown in Figs. 1028, 1029, the first from the church of S. Blasien in Mühlhausen with an indication of the rectangular form of the ashlars, the latter from the choir of the cathedral in Erfurth formed of the wash. Of such a kind are the massive profiles of the plinths of the church of S. Maria at Mühlhausen.

It is self-evident, that for the members of the plinth should always be selected, as generally for the entire base of the building, stones particularly permanent in the weather, and the same applies to all strongly projecting parts. On plinths and bases of columns and piers further see p. 212.

3. Architectural Treatment of the Buttress.

General form of the buttress.

Required dimensions.

The general form and dimensions of the buttress were specially treated in the earlier Sections, to which we therefore briefly refer here. First was demonstrated on p 125 to 127 what form of elevation would be most favorable for the effect alone of the wind (Fig. 343), and what types of elevations are chiefly followed in executed buttresses (Figs. 344, 345, 346). On p. 163 and 335 are then considered other side forces and especially wind thrusts, it was shown there (p. 335) how under their influence

might be required not only increased strength, but also a changed form of the elevation, while side forces applied very high made too great diminution of the buttress unsuitable, and it m must rather be carried up in approximately uniform dimensions. The calculation of stability against wind thrust was explained on p. 163 to 170, and further the calculations for different examples of buttresses were made on p. 336 and 402.

Taking a buttress like that of Fig. 1030, the following course of investigation must be recommended. First is obtained with only the effect of the vault thrust the location of the pressure in the base I and the top of the plinth II or II a (p. 140), and there is determined in the given case the stress occurring in the material (p. 143 to 145). Then is added the effect of the wind, first from the left and then from the right, and the resulting displacement of the pressure is found.

With the wind from the right in some circumstances occurs a greater side force S, which then makes indispensable also an investigation of the stability for the section III. If this force S be nearly horizontal, then must one consider also whether a sliding of the upper masonry can occur at the bed IV, or V, or one lying still higher (p. 340). In case this is to be feared (i.e., if the resultant of S and the loads varies less than the angle of repose from a perpendicular), the upper loads are to be increased correspondingly by masonry on the buttress or the side walls. On an investigation including the side arches or t the upper part of the wall with this, see p. 338 to 342.

Offsets.

If the dimensions and general form of the buttress are determined, whether indicated by accurate or approximate calculation, by empirical rules (p. 273), or by direct estimates based on p personal experience, then it is next to treat it architecturally. For practical and artistic reasons one seldom reduces the buttress with a single slope or batter from bottom to top, but in both thickness and depth reduces the mass, and whose copings as well as the upper termination of the buttress can afford opportunity for the most varied forms. The mass taken away by offsets at one place must me more or less added again, and the offsets must not be cut too deeply into the body of the buttress, and in any case must not be exceeded limits, as indicated by oblique lines in Figs. 1032 to 1034. The offsets must generally

not be too great and not effect changes in intermediate cross sections.

At an abrupt offset as shown by Fig. 1031, the force D in the upper part would exert a strong pressure near the edge A, that must be transferred to the point C of the lower part. On the contrary the directly adjacent point E that has no load and has a pressure = 0, so that the danger of shearing increases between the points C and E. in fact here with the small resistance of the stone masonry to thrust or shear may result very easily a separation of the parts, which continues far below in the form of a crack, as can be frequently observed on old and new works. (Moreover it not rarely occurs besides on secular buildings on the parapet wall beside strongly loaded window piers). The old masters did not overlook this point, they used here particularly strong ashlars, or they also used cramps, and in brick buildings there was sometimes alternated here the positions of the courses.

But it is more effective to make gradually the change in cross section corresponding to the spreading of the pressure, which is to be effected by steep slopes, inserted gables or other partly transmitting and partly loading pinnacles or the like.

If the buttress has only one offset, it naturally finds itself placed at the height of the internal capital or springing of the vault, for at this place occurs the thrust of the vault, which requires an enlarging of the abutment downward; by the projection would also be indicated on the exterior the point of application of the internal thrust (Fig. 1032). Instead of one may exist two offsets, one above and the other below the capital (Fig. 1033); the latter can be placed so far downward that it combines with the sill course (Fig. 1034). If the number of offsets be further increased, they may be of uniform size or be alternately larger and smaller. The division in height can either make one part predominant, an equality, or exhibit a pleasing reduction or a rhythmic change in heights, but the relation of the different parts to each other must be clearly expressed and easily perceived.

With the projection in front may be combined a more or less great projection at both sides of the buttress.

In the instructions of Lacher (Note) the height of the capital in the interior determines the height of the lower end of the

offset of the so-called drip moulding. Thereby the before mentioned importance of the offset is indicated in the clearest way. For the dimension of this offset is found there the rule, that its area above this remains square, if a pinnacle stands thereon. This determination must at the same time also indicate a limit of diminution for the simpler form. Where as on the church of S. Elisabeth in Marburg and the church in Wetter, the part of the buttress above the drip moulding finds itself smalles, there is to be sought its ostensible purpose in the support of the gargoyle, while the proper buttress ends with the supporting moulding.

Height of the buttress.

Note. Reichenaperger. Vermischte Schriften. Leipzig.

As for the height at which lies the termination of the entire pier, for this is set a maximum for ordinary cases, that the cap stops beneath the bottom of the roof cornice or of the gutter. It extends exceptionally to the upper edge of the cornice, so that the roof of the bulilding projects over the buttress as on the church at Haina (Figs. 1035, 1035 a), or the roof cornice extends around the buttress and its cap, adjoining the balustrade of the roof cornice in which the buttress here appears favors the united effect of the whole, and therefore is effected in another way. Thus are found on many early French works on t the low cap of the buttress is set a part reduced on all sides, whose projection equals the projection of the moulding. This portion of the buttress then stops under each projection. Such an example from the choir chapel of the collegiate church of S. Quentin is shown in Fig. 1054 at a. Sometimes that part of the buttress is replaced by a column, whose capital grows out of the cavetto beneath the gutter (Fig. 1055).

Other combinations result from the arrangement of the gargoyles, as well as from the pinnacles placed on the buttresses, t that can be developed with particular freedom, if the buttress rises to receive a great load above the height of the cap.

Caps of the buttress and of their offsets.

Cap in the form of a shed roof.

Figs. 1032 and 1033 contain the simplest form of cap, namely that of a shed roof leaning against the wall. The rate of inclination is arranged according to the construction, as a horizontal position of the joint requires a steeper direction (Fig.

10 7), and a joint perpendicular to the inclination allows a flatter one (Fig. 1038). With the last construction, that results from the use of mixed materials , the beginning aud also the close of the coping at a and b must be bonded at right angles to the buttress and the wall. If according to this construction the ashlar lies at top with a bed resisting the weather, for it is still the disadvantage, that the joints are more exposed to the penetration of water than in a horizontal position.

The sides of the buttresses that remain without protection in the form assumed in Fig. 1032 may receive such by the breaking and coping around (Fig. 1033). The wash of the latter may either have the direction of the cap of the pier or be flatter, hence with a bend formed against it (Fig. 1033 a).

The next addition consists in a moulding accompanying the angle of the coping of the buttress, that stops on the horizontal wash (Fig. 1037), and either is different or the same profile as the latter. Thereby results further a stopping of the horizontal moulding at the side surface, so that only a short piece extends around the corner (Fig. 1039). Most simply the horizontal profile directly forms the horizontal (Fig. 1040), but not well possible without a distortion of the profile.

A bending of the gable moulding horizontally (a b in Fig. 1041) forms the simplest means of breaking it around the corner and so connecting it with the horizontal continuation, so that the profile remains unchanged, and it also finds its application to actual gables of greater dimensions.

The length of this piece can be reduced so that the inclination of the roof starts according to Fig. 1041 a near the extreme projection of the horizontal moulding.

In the later periods the bends on buttress caps are found replaced by a concave line of inclination of the coping as shown in Fig. 1042. Indeed the purpose of an unbroken course of the profile is thereby obtained in but an imperfect way, and there always occurs a distortion of the latter increasing with the radius of the curve, and hence is most striking when the line of inclination is again straight.

This combination of the gable and horizontal mouldings can further be attained by omitting the return, with an intersection (Figs. 1043, 1044), an arrangement that allows entire freedom

to the profiles of both mouldings. In certain works of the later periods the mouldings are prolonged beyond the point of intersection and then cut off at right angles. But further the intersection may also be avoided by placing a neutral body between them on which both die (Figs. 1044 to 1045 a). On earlier forms of this kind is expressed in a certain manner also the function of support in the form assumed for this intermediate of ... volutes extending from the angle of the buttress, as likewise made the ground motive of the form of a capital (Figs. 1044, 1044 a). Instead of these was also an animal form, a head or finally a freer form of leaf could appear, which usually scrolls from the lower member of the gable moulding (Figs. 1044, 1045 a), then merely forming an intermediate. Since now in the Early Gothic period those volutes also serve the most varied purposes and a purely intermediate character, this in later times is true is true of the pinnacles, which therefore also appear here in a position corbelled from the angle of the buttress, and both alike or different mouldings can stop dead. Thus generally all general conditions are reflected in this apparently trivial detail.

Combination of shed and gable caps.

By the arrangement of the simple shed cap the water drops from the drip moulding of this on the lower offsets. But over the angles the water can be led by the combination of the shed roof with a gable above the front side of the buttress. (Fig. 1046). The gable may be formed with or without a projecting moulding resting on a horizontal moulding, or it may be in connection with bordering the shed roof in any manner. Further the horizontal moulding can also be omitted and the gable moulding be cut off abruptly in the side surface, the gable may extend over the entire width of the buttress or may have a smaller breadth, the gable roof may extend horizontally along the shed roof, or the ridge of the same can be parallel to the inclination of the latter.

As for what concerns the profiling of all such inclined mouldings, an intersection is not absolutely necessary, since the w water running over the front edge down over the hollow or chamfer will flow away at the angles; therefore it contributes a c characteristic form differing from the ordinary profile of the drip moulding. Of ugly effect is especially a too great height thereof. Hence an exact proportion of the height of the gable is not to be fixed, since in smaller dimensions this must be

greater than for small dimensions; generally suitable proportions can be found by dividing the base of the gable into 6 or 9 parts.

Above the angles of the buttress the gable moulding meets one accompaning the slope or lying on the longigudinal surface of the buttress, and thereby may result long hanging points according to the nature of the stone (a in Fig. 1047). Hence they are generally cut off at the line b c. But further is arranged a corbel beneath the surface so resulting, or finally is employed such a one with a horizontal form (Figs. 1044, 1045). The arrangement of a pinnacle at the point in question leads to the fully developed system of the intersecting gables on the pinnacle.

For a complete regulation of the course of the water above the angles is further very necessary an elevation of the gable moulding above the roof surface, as shown by the Greek cyma, and t that here as a rule is formed by a returned gutter;. Thereby a are formed water basins above the angles, and hence the need of spouts or gargoyles. Fig. 1046 shows such an arrangement.

Covering like a gable or hip roof.

Instead of the compound roof design is usually found a simple gable or hip roof extending along the depth of the buttress in a horizontal direction to the face of the wall (Fig. 1034), which again may receive a richer form, so that it is penetrated sidewise by one or more.

On German works the roof surfaces are generally left smooth. On English works are usually found the rectangular or undercut form of the edges of the separate ashlars, and on the French is the scalelike theatment of the surfaces with rectangular edges. (Fig. 1046). This essentially contributes to the animation of the whole and shows how skilfully the ancients understood how to give to a part a decoration corresponding to its function, and at the same time to facilitate the removal of the water. (Viollet-le-Duc, V, p. 101). On the form of the gable this work on the surface has an influence, since its profile can form the limitation of the line of the gable (Fig. 1046 a). For a raised gable moulding it runs on the contrary (Fig. 1046).

The gables either remain plain or can be filled by a circle, trefoil, tracery or foliage ornament. If the horizontal moulding is wanting at the base of the gable, as a rule there a blind a arch is in the gable.

The ridge of the roof of the gable would only be sufficiently obtuse that its slight inclination to be executed, and it therefore could be strengthened by an accompanying round or pointed moulding (a in Fig. 1046). The profile of this member forms in front view the simplest form of crowning of the gable (Fig. 1048). A more perfect form of it would be obtained by placing on it a stem with knob. The motive of this arrangement results from the construction of the pyramidal stone roof, as shown later, but likewise from that of the wooden gable roof, and it forms a detail much exposed to overloading in form and size. Therefore we shall attempt in the following to give some developments of such forms certainly based only on views od mediaeval works.

Let the triangular gables in Figs.1049 d, b, c, whose heights equal the base with a cornice an eighth the height of the latter, the side Fig. 1049 a shows a section through the ridge. If we now assume that the lower joint of the stem set thereon passes through the point a, then will e f be the rise of the required ashlar, thereby determining the projection of the crocket. But in any case even with a varying location of the joint there results by the verticals erected at a and f a relation of the size of the crowning to that of the crowning of the gable cornice. The lower size of the stem is then found by an extension of the line a l to the side of the triangular gable and thus to m, the upper by the triple division of i k. According to the assumption of the intended form, further considered below, of half the side of the square on i k remains to e g and f h in the section in Fig. 1049 a behind the projection of the gable, so that the stem is set back from the front face. Different determinations of the dimensions are contained in Figs. 1049 b, c, where the width e f is always taken as a masis.

A development of the height of the crowning from that of the gable is unsuitable, there occurs almost a converse relation between both. Evidence of this would be given by trial, that for the low gable in Fig. 1049 d the assumed proportion would exceed that represented on the steeper one in Fig. 1049 d.

In general a polygonal section of stem and knob is preferred to a square one, by which an excessive size would be produced diagonally. The polygonal stem can then intersect the roof of the buttress or return to the square.above the junction, and in any case occurs an intersection with the moulding crowning

the gable (Fig. 1049 c). If the gable cornice ends with a drip above, the polygonal stem usually has the position given in Fig. 1050 in plan on the upper edge of the drip, and there is found either as in Fig. 1050 a, b, a transition by a bending of the angles of the stem, or a simple intersection occurs of stem and gable cornice. The form of the gable becomes richer if it is adorned by leaf buds or edge blossoms, which are then best placed at the middle of the stem (Fig. 1050 e.

Covering the offsets.

Everything said here concerning the caps of the buttresses a applies in like manner to the covering of the offsets. But it is in the nature of the matter, that all combined forms require a certain size of the setting, while every small offset of only a few inches is satisfied by arranging a simple shed roof with drip moulding.

Side offsets in the dimensions of the buttress can be connected with those in front and thus with the front shed roof, and then either as in Figs. 1051, 1051 a, the drip moulding may extend along the sides of the buttress or be omitted as in Fig. 1051 b. In Fig. 1051 a the inclination of the roofs on the different sides need not be the same, so that thus a different size is obtained.

Further each of the forms shown above for the caps of the buttresses may also form a composition placed on the buttress diminished on the sides. A compound arrangement of this kind is shown by Fig. 1054. This form may be changed in a particularly effective way, so that the piece on the buttress reduced in thickness may be combined with that set on the buttress reduced only in depth (Fig. 1052). Such forms are found on the towers of the south transept of the cathedral at Laon as well as on the central tower there (Fig. 1055), and produces a good effect especially by the multiplication of the angles. On the contrary on English works is sometimes found a simple chamfer of the angle, which then in a richer way is obtained by rectangular recesses in them with inserted little columns, so that cap and base form the transition to the right angle.

In the later periods of Gothic art the cap is usually formed by one or more of the ground form to the diagonal, and thus likewise is made a multiplication of the angles, that is then led on certain works to a semicircular ground form of buttress.(Fig.1

Enrichment by blind arches and shrines.

Blind arches.

The richest ornamentation of the buttress results from the use of blind arches, capable of the most diversified forms. The adoption of these makes necessary an enlargement for the material cut away by the blind arches, and the members of the blind arches best project entirely. Lacher says of them:- "It is then best that thou wilt break it up with tracery, so leave only its length and thickness." The buttress of the church of S. Quentin r represented in Fig. 1056 forms in a way an Early Gothic illustration of this text, so far as shown in Fig. 1056 a, the blind arches are formed by little columns projecting from the front surface, which stand on the lower projection and support the arches inclosing the blind recesses joined to the mass of the butt

If the blind arches e?tend around the buttress, then would be necessary an increase of its thickness by that of the columns. Richer arrangements result from upper and lower divisions as in Fig. 1056 a, whereby only the former and larger columns of an entire piece project, and the smaller ones are wrought on the ashlars of the nucleus. Thereby either the former can be accompanied by the latter as by wall pilasters (right half of Fig. 1057), or only receive the arch on its capital, as shown by the left half of the same Fig.

On the buttresses of the clearstory of the church of Nantes are lacking the arches set on the columns, and their capitals directly bear the roof of the buttress. In the converse sense are found to predominate in the late time the arched members in vertical spandrels extending down to the base, so that the columns consisting of pieces are omitted, and at most recur still in the capitals and bases by which the rounds of the members extend downward are ornamented.

To the arched work and tracery is applicable what is later s said of window tracery,. But a peculiar condition concerning the height of the arches results if the blind arches enclose a part of the buttress terminating in a simple gable roof. For here the height of the capital is determined by the need for t the crown of the arch to remain below the horizontal cornice of the gable roof. Therefore the arch on the gabled side must either recede to a greater depth below the line of the gable as at a in Fig. 1056, so that in a richer form above there can be

found a place for tracery, or it must be stilted.

The proportions of the little columns and mullions may be developed in different ways. In the plan of Fig. 1057 we employ the proportion of 1 : 4 as mentioned elsewhere in regard to the window mullions, so that the entire width is divided in 54 parts, of which each division receives the inscribed number of parts. This proportion is also one suiting open shrines, where the interior is vaulted, since it about agrees with the thickness of the abutment for the stress in the arch. Meanwhile in the case mentioned yet a little increase occurs with regard to the square form. To entirely similar results leads the geometrical construction represented in Fig. 1057 b. In this a b is the entire width of the surface concerned, a c and b c are the diagonals of the square formed thereby, so that half the difference of b both lengths determine the diagonals of the angle square adef, and the intersection of these with the diagonally placed equal area g h i k gives further starting points for the form of plan of the arch members and of the little columns placed beneath them. Thus on the assumption of a combined arch system with large and small mullions, the plan of the latter being imitated for the corresponding part of the larger in both halves of the Fig. in different ways. Meanwhile also in regard to a single blind arch the small mullions vanish and generally the form of plan becomes simplified, about as shown by the finial represented in Fig.1057.

As generally in smaller proportions an enlargement of the projecting parts , an addition of certain dimensions connected with the natural conditions occurs, so that such a one is first given for the analogous blind arches of the body of pinnacles as given by Roriczer in the "Little book of correct finials(Figs. 1067 to 1067 e)aand p. 458.

By removal of the masonry nucleus and covering the resulting open space became the parts of the buttresses furnished with blind arches at Gelnhausen, that first serve to receive figures.

Shrine with horizontal covering.

The simplest form of this is that mentioned above and allied to the buttresses of Mantes, entirely separated from the vaulted construction, while from the free columns to the back wall, thus a slab is laid over the buttress and on the latter is placed a gable roof. Fig. 1058 shows such a form from the south transept of Strasburg minster, which occurs still later on the south tr-

transept of the church at Colmar, as well as also on the cathedral of Chartres and other Frence works. In a richer form this arrangement is found on those two intersecting gable roofs and the placing of a crowning over the crossing, this almost leading to a colossal pinnacle, like this development in Colmar, there indeed in very low proportions. On account of conditions and generally from the severe character of the detali forms peculiar to that early time, still the horizontal covering becomes nowise peculiar to the transition style and is to be regarded as contrary to the Gothic principle of construction. It is evidently not the latter, for so may be developed tha vaulting system always, and thus in no period is excluded the horizontal covering. Everywhere appears the latter as an extension of the former, indeed as an independent form of covering, where permitted by the span to be covered. Accordingly it is decidedly in the nature of gothic art to develop the entire structural form into an art form, i.e., to employ all those details, in which the decorative character appears in the foreground. When further gothic art in this very rapid development soon passed from these forms of the early period to those more graceful produced by the development of vaulted construction rests more on the choice of these ornamental forms of details, than on the recognition of the incompati bility of the earlier basal motives with the fully developed form of construction.

Shrine with tunnel vault.

A symmetrical support of the slab results when the columns are connected with a back wall by stone beams laid across and project inside, which either form the entire mass or bear a gable roof constructed of inclined slabs. Fig. 1059 exhibits such an arrangement, that in its further development leads to a tunnel vault, indeed first to one formed like the trefoil arch, by a repetition of the corbel form at top; Fig. 1060 then shows a tunnel vault, whose pointed arch is then included within the triangular gable, while those stone beams form its abutments; Fig. 1060 a shows the plan of the little columns at a greater scale with the moulding at the front of the vault and the stone beams, and Fig. 1060 b is the section. The jointing is arranged according to the magnitude of the whole and in smaller dimensions wouldllead to the combination of the vault with the roof in two pieces with a joint at the crown of a member covering it and

forming the ridge.

Shrine with cross vault.

Meantime the tunnel vault is also soon found to be supplanted by the cross vault (Fig. 1061), and there is indeed expressed a least apparent result of this course. For the principle may well be established, that since onle the system of choss vault determines the entire body of the structure and in general the development of all its members, the exposition of this condition in all dimensions is required, as soon as it concerns covering a space, and this explanation may appear grounded, when the circumstances allow it to form the entire covering of a single block, since it concerns only the imitation of a structural motive for a decorative purpose. But when the proportions of the space to be covered lead to vaulting with actual joints, it will be required to appear by a higher result, just to adopt the form of vault best suited to the conditions and dimensions. Thus we find the tunnel vault in the best period of Gothic frequently maintains its place beside the cross vault, as above the passages extending before the windows (p. 855), as well as over the projecting porches of the cathedral of Amiens and that of Chalons built between the buttresses. Indeed we even see it developed particularly to a richness, that excels all later applications of it, such as brought by the Renaissance and Rococo styles, and even affords a rich substitute for the more varied lines of the ribbed vault. If then and particularly in the later time the cross vault also in cases where the proportions of the ground form and the considerabel difference of its sides first requires the tunnel vault, as in the example last mentioned, and even appears with a certain affectation, no blame will be expressed here, but only will be asserted the freedom of the use of the simple form of vault and first in regard to the shrine. Certainly diversity will be obtained thereby without damage to unity.

To buttresses, little columns and capitals on shrines covered by cross vaults apply what has been said concerning piers and vaults.

Supports of the shrine.

In Fig. 1057 a we take the square a b c d found in 1057 as a basis, from which result the dimensions of the separate parts of the arch as of the little colunms forming the buttress. Instead of the buttress there could be a single column according

to the earlier mode be arranged, or according to the later buttress with attached little columns. The ribs require by their small dimensions a simple moulding, a round or pointed bowtell, or this can be replaced by the compartments in which the ribs meet.

Proportion of the height of the shrine.

The proportion of height of the shrine are made moderate on the older works, about 3 : 1 to 4 : 1, and so far depend on the figure to be established therein, so that the head of the latter may not rise above the top of the capital as a rule, but more commonly remains below it. More slender proportions are obtained by the arrangement of blocks or pedestals on which the figure stands, and further by placing it in a free column. Smaller columns are usually employed by arranging iron anchors at the height of the base of the vault.

Form of plan of the shrine.

The ground plan of the shrine is square or rectangular. The latter form in the proportion of 1 : 2 in the interior can be combined with the square form of the exterior in the manner shown in Fig. 1061. Yet the rectangular form is also fully exposed, and is even connected with a concentric form of pointed roof, so that the excess of the side of the latter beyond that of the shrine either intersects the face of the buttress or rests on a projection from it, and hence the middle line of the roof of the smaller side is entirely separated as at Rheims. M Moreover such irregularities were never feared, since then merely heightened the picturesque effect.

Likewise the polygonal plan is sometimes found, first that of the hexagon so that the shrine proper projects from three sides of the hexagon, and a niche made in the rear wall completes the entire polygon. A polygon with more sides would cause the disadvantage, that the columns would conceal the figure. Yet such a defect is sometimes avoided by replacing the two front columns by suspended springings of arches.

Crowning the shrine.

The idea lying at the base of the use of the cross vault on these details is that the decoration of the principal form of the whole becomes the most definite expression, if there is assumed over the vault a horizontal cornice and above theis a gable roof with gables over the front, just as over church vaults are found ceiling beams with a roof above them. With a square

ground plan the same treatment of the different sides leads to a repetition of the gables above the sides, and thereby to the arrangement of two intersecting gable roofs. Further the endeavor for greater lightness leads to the omission of the horizontal cornice and to raising the vault into the interior of the intersecting roofs, whose surfaces then form only the external surfaces of the vaults. But the intersection of the roofs makes a s special accenting of the point of intersection by an ornament an esthetic necessity, just like the intersection of nave and transverse aisle demands the arrangement of the central tower. The nearest form of this addition is the pyramid, i.e., the great pinnacle by which the charcater of the shrine passes into that of a hollow finial. Thereby the weight of the mass of the omitted nucleus is replaced by that of the figure of a saint placed in the shrine, and certainly a happy thought lies in this, that of expressing in the stone construction the strength imparted to the church by the importance of the saint.

With the buttress may be combined the shrine in different ways, either forming a termination of it or an offset. In the first case it lies in the wall surface or rises above its top, in the latter it either lies before the top of the buttress in a smaller width or has the same breadth, so that the architecture of the shrine continues as blind before the solid mass of the buttress.

Buttresses extending to the roof gutter and carried above it.

Also the relations are of the greatest importance, that the buttress has to the gutters and spouts.

Supporting the spout for water.

The simplest arrangement consists in this, that a part of the buttress in its thickness bears the spout, as on the choir of the church in Wetter (Fig. 1062). In the simplest case it has the same width as the spout, but may exceed it, so that it may project beyond that and the excess receive a cap under the spout, and for more ornate designs a little column would project from the buttress, on whose capital the spout receives another bearing. Such an arrangement appears to be intended on the buttresses of the eastern bay of the south side aisle of the church at Haina.

On the cchurch of S. Stephen in Mayence is then found the ar-

arrangement represented in Fig. 1063, where on the gable roof of the buttress is set a detached column, which supports the spout, where a strongly diminished part of the buttress formed as a square set half diagonally forms the first support of it, so that the adoption of this ground form beneath it occurs in connection with the chamfer bordering the lower edges. On the same construction is further based the frequently occurring design, according to which the column is replaced by a detached pinnacle (Fig. 1064), in the body of which the penetrating spout forms a course, so that the upper part or the body of the finial is ensured by loading the entire construction.

On S. Benigne in Dijon is found the form shown in Fig. 1064, which offers a suitable motive for the arrangement in question. Indeed the same appears to be substantially modified in reality and we have not been able to obtain the existing direction of the water therein. Therefore we give Fig. 1064 from a sketch w with the spout placed at its foot with only the addition of the front mouth of the spout projecting over the pinnacle. The absence of the spout indeed permits the possibility of a later change, so that the pinnacle forms or contains a vertical tube, through which the water is conducted to the gargoyle. The arrangement in question is further found in full activity, though in simpler form on the towers of the church at Volksmarsen.and on that in Wildungen.

A design belonging to the early time of Gothic art is further shown by Fig. 1065, where the buttress is enclosed by the roof cornice, so that on its upper surfaces is formed a water basin, from which the water runs into the spout placed beneath. Next this would be the last arrangement, whereby the width of the basin is divided by a gable roof so as to leave at each side a gutter extending to a spout. There the gutters like the gable roof may be inclined, and the spout be replaced by two spouts set diagonally.

Extending the gutter around it.

The division of the upper surface into two gutters then chiefly occurs with entire necessity, if the buttress has a projecting part or a pinnacel rising above the gutter, the water being carried around that higher part instead of through it. We find these particularly on the buttresses of towers and on the arrangements in other places in connection with the buttress system,

and mention here only those of the S. Chapelle in Paris, where the buttress is enclosed by the complete double roof cornice, so that the difference between the upper surface and the section of the pinnacle obtained by this projection gives the width of the gutter, from which the water is ejected through beasts set diagonally. This difference of the surfaces would have remained useless, unless the pinnacle projected there and was thus corbelled out beyond the face of the buttress.

Conducting the water.

All the arrangements mentioned show a conducting of the water in the open air, and thus afford the advantage, that any stoppage is easily seen and removed. Conducting the water through the buttress on the contrary usually ensures the advantage of a shorter course. Such outlets are generally more perfect, since t they are larger and the bottom is maintained with the greatest certainty. The last purpose is best attained by overlapping slabs with drips in the direction of the water (Fig. 1066).

For high buttresses the parts above the thrust alone increase by their load the resistance. This condition is most clearly e expressed by extending the buttresses above the roof cornice, which then in the simplest case terminates with a gable roof, when the knob crowing the latter either is over the front or over both gables, or with an increased size can be placed over the middle of the ridge. This increase has its reason in that it concerns the bringing of the crowning into proportion to the length of the ridge, and in its greatest extent leads to p placing a great pinnacle.

Concerning the position of this part of the buttress it is to be stated, that if no stone gutter exists, a development of it from the roof causes certain difficulties in regard to the addition to the roof, which produces no good effect by direct contact of the smooth surface of the buttress, or that adorned by blind arches, with the rough surface of the roof, and this is better avoided, so that the roof cornice passes behind the rising buttress and even leaves a small interval between them.

By the principle of loading is given a means to reduce the other factors, the resistance of the buttress, thus the thickness and width of this cross section. This condition is then e expressed first in this, that the profile of the buttress again approaches the vertical, which is then broken by the different

offsets and their caps sometimes ornamenting only to a few inches.

As stated elsewhere, buttresses risinm tolerable vertical and quite strongly loaded above are in place, particularly where very high thrusts occur (p. 335). The upper loads at the same time afford the welcome opportunity to develop tall and gracefully tapering crownings, that in the course of time come into ever increasing use in the form of pinnacles.

4. Pinnacles.

Construction of Pinnacles according to rules of the old masters.

Chiefly in their connection with gables and tracery, pinnacles form a particularly prominent group of Gothic forms of development and in their extremely diversified forms and combinations substantially contribute to the richness of the whole, but like tracery extend almost to overloading. Thus were regarded from the 14 th century as given magnitudes, and as the common possession of all materials and trades, they were employed for almost every conceivable purpose. If then in the middle ages such exaggeration always occurred with skill and good luck, such is not to be praised in all modern applications.

Pinnacles according to Roriczer.

From the last times of the 15 th century the "little book of correct pinnacles" (Note) with an appendix on the construction of gables, which gives correct determinations of the dimensions of certain kinds of pinnacles, more ornamental and kept within smaller dimensions, that we shall follow here in an extract.

Note. By Matthes Roriczer, cathedral architect in Regensburg; Reichensperger, Vermischte Schriften.

In Fig. 1067 let a b be the square plinth of the pinnacle, t then are determined by the inscribed diagonal square the two squares next found, the plan c d of the shaft of the pinnacle and the bottom e f of the recesses formed therein. Then divide f g in 3 parts, lay off 2 of these to h, and thus is determined the quadrant struck from h with h g with its fillet forming the moulding of the body at the recess. Then describe the rectangle g g k k, so that k g = 2 g g, and thus determine the line l m drawn from l determines the projection of the crocket, whose plan is l m g g m. Likewise the distance between the two outside squares determines the projection of the gable cornice. From these results the elevation of the pinnacle as follows:- the height

of the body including plinth = 6 a b, that of the latter = a b, and that of the pinnacle = 7 a b as given in our Fig. By the same numbers, the upper width of the pinnacle = 2 h g on the plan. The ridge n of the gable is then 2/3 of the height from 6 to 8. Since then the extreme point of the projection a results from the plan, then the slope of the gable is a n and by o p parallel to the same is found the height of the gable cornice. The extension of the lower line of the cornice to the upper one, thus from o to p gives the width p p as the lower width of the stem, whose upper and middle is determined by h g of the plan. Further 8 g = f h on the plan, and the two squares q r s s are constructed on the middle line with the same sides, which gives the dimension of the knob crowning the stem.

The points 11 and 12 then give the upper edges of the moulding separating the pinnacle from the crossflower and the flower itself, whose projection is determined by the plan square a b and its height t u by 1/3 of the side a b. The distance between the two squares a b and c d in the plan further gives the width 13 v, while the widths v w and 11 x are determined by 2/3 of t u, as well as the height of the top knob and of the moulding under the flower. The projection of the knob results from the square e f in the plan, and that of the cornice by the square c d there, the under edge of the crockets are finally given by dividing the distance 6 8 into six parts, and their heights by the distance m m in plan.

By further execution of the form of the crocket then results the form of pinnacle given diagonally in combination and drawn in connection with the curved window gable. In the frequently mentioned Instruction of Lacher is found still different determinations of the heights of pinnacles besides those agreeing with those of Roriczer. According to one should the body of the pyramid have heights of 8 a b, a proportion that he calls the "fresh division", according to the other the body has 7 and the pyramid 8. But the use of such slender proportions he makes dependent on the goodness of the stone, and further whether the pinnacle shall stand in the drawing. But generally in Roriczer as in Lacher, it is recognized from the entire combination, that the given determinations relate to pinnacles and rather an ornamental function on buttresses adjoining or bonded to wall surfaces, and especially when combined with window gables and kept

within moderate dimensions, but not to thus more structural uses, that load the buttresses and terminate their forms.

Window gables according to Roriczer.

We shall here also follow the construction of window gables according to Roriczer.

The distance on certres of the pinnacles in Fig. 1067 b measures 6 a b. With c d circumscribed about the squara ab in Fig. 1067 c gives as e f on the centre c of the pinnacle set back as the angle and in the intersection with that likewise set diagonally the dimensions of the jamb and division of the mullion for the blind arbh or the window, which will be crowned by the gable. The profile of the latter then results from the equilateral triangle constructed with the side g h. By Roriczer this is developed in the manner shown in the side Fig. 1067 d, thus with a concave hood in plan, but a different form of corresponding elevation and a different basis with the corresponding form given at g h i. The line k k drawn through the end k of the hood gives the middle line of the normal square of the crossflower of the gable, whose outer square determining the plan of the 4 leaves l l in elevation coincides with c d. The second square n o gives the plan of the stem moulding n o in elevation, the third q rthat of the top knob q r, the fourth s t is that of the stem at s t above n o, and the last u v is the top plan of the stem. It is then to be noted that at top the square is changed to an octagon.

The height of the pinnacle then determines that of u v, thus the point of the crossflower on the gable, whose total height from u v to x is fixed at 1/3 the height of the pinnacle. The separate heights of these are given in exactly the same proportion as on the pinnacle, so that for the side of the outermost square a b there taken, the side l m enters here, etc. By the connection of the plan of the stem s t and u v and the extension of the lines concerned downward, results then the diminution of the stem of the flower, on whose border line will be tangent t the outer arch of the curve of the gable. Thelatter can be constructed as follows. First draw the plan of the gable, thus the profile g k i h in the plan of the pinnacle at the place from which it shall go, here then in the projection of the plinth of the pinnacle. Then strike the separate lines determined by the profile of the window arch from the assumed centre, here at

z in Fig. 1067 b and further by the separate concentric arch lines resulting from the gable profile. Then erect at the point x a line x y perpendicular to the diminishing line of the stem, and seek on the latter a centre, from which can be struck an arch tangent to the line of the stem and to the outer line of the arch, and accordingly strike thus concentric with this and the other arch lines of the gable. In a corresponding way, as given in the right half of our Fig. could be constructed an angular gable with straight lines. The projection of the leaves resting on the wash of the gable from the extreme corner of the profile, thus q r, and likewise their height n r, are determined according to the lengths on the plan similarly lettered, and the distribution of them on the outer arch of the gable is made.

Pinnacle according to Lacher.

That the construction developed above agrees in a way with t the examples given by Lacher, yet they only afford even a greater freedom.

What first concerns the proportion of the width of the whole, this is the distance between the pinnacles, it only requires that the distance between the pinnacles, "the width of the gable," will be determined by the side of the square of the plinth of the pinnacle, but it is left free whether this side shall be taken 8, 10 or 12 times for it. On the development of the elevation of the gable, whose principal divisions he gives to correspond to Roriczer's (Note), he derives the construction given in Fig. 1067 b of the arch lines from those of the stem, "when thou hast the stem of the gable, thou canst draw the arches therefrom; some gables have only a half circle, also some are higher." Since he now fixes the total height of the gable to the point x in Fig. 1067 b as 2/3 the height of the pinnacle, it follows f from this that the radius of the upper partof the arch causing the ogee curve is in an inverse proportion to that of the lower, and therefore with a straight course of the spandrel of the gable = 0. Of the crossflower he says further, that some need a great and a small flower, since it will indicate in the distance it will show as well also the knob, so that by thickening is to be made with the circle as a basis.

Value of these rules.

We remark that we have not given these rules of the masters dating from the latest times of Gothic here in the sense, that

the proportions obtained by them should be generally determinative. Such a claim was at least in the mind of their inventor, since then Lacher in particular gave this instruction to his son, only to cause him to learn the parts concerned and their forms, but emphasizing everywhere the greatest freedom in their application. And here might we generally restrict the true use of all such rules to this, that they give to beginners useful explanations, but nowise should form a criterion for the value of any other form. In reality almost every pinnacle according to its position requires a special development of its dimensions, and particular proportions. The most important and significant function of the pinnacle is that, from which we started, namely the loading and termination of the buttress. We must therefore seek to develop the leading idea of the entire form on it, and therefore show that in one case a stumpy form, in another case a more slender pinnacle is in place, thus the master's rules of the late period very soon refuse their service. As already stated, the rules appear to relate only to that time of everywhere springing and more ornamental pinnacles, which already results that they appear to have been conceived as made of a single stone. When several blocks are in question, there occur other conditions, as on an example represented in Fig. 1068 might be explained in regard to the projection of the crowning.

For the side length a b (Fig. 1068), let 75 cm be assumed as an ordinary thickness of the pier for moderate dimensions, and the height of the pyramid a b 4 may be laid off as 4 times the base. Hence the total height of the pinnacle will amount to 3 m, and it will also be composed of several blocks. If the available thickness of the stone is 40 cm, and if the top of the pyramid is a stone set on end, then as c d e f shows, that would not make up half the height if the projections of the bosses still remain in it. The upper knob is also naturally included within these limits, so that projections such as Roriczer gives for t them are evidently forbidden.

In our Fig. 1068 the crowning consists of the stem supported from the pinnacle by a moulding g h, the stem and the roll knob, and the height of this part is obtained according to the division in 5 parts frequently given by Lacher, the projections as noted by the width c d, the lower thickness of the stem by extending the outline of the pinnacle to g h.

Different forms will result by raising the moulding on the s stem about one fifth, or by simplifying or by omitting the stem moulding (Fig. 1068 d).

Crowning of the pinnacle.

Necessity for the crowning.

Cutting the upper block into the sharp terminal point of the pyramid is hindered by the nature of the material; but the assumption of a frustum of a pyramid gives an imperfect form and therefore is opposed to the conception of a termination; Hence it is necessary to find the form of a crowning fulfilling those conditions. The need for crowning all points existing in the u unity as one so common to all architectural periods, that it can pass almost for an innate idea. Thus is found the crowning of the apex point on the pagodas of the Hindoos, the towers of the Chinese and the pyramidal works of western Asians. So the Greeks crowned the pediments of their temples and ridges with the figures of the gods or with acroterias and facing tiles. T Thus the dome requires its crowning, although the pole is here only a point given by the position and not by the peculiarity of the body, in the measure that it usually acquires a definite expression. It is proved by the high domes of the Renaissance compared to the Roman composed of circular segments. The form of the crowning varies with that of the body, and the ridge of the roof requires a continuous cresting, the dome a concentric one and thus a crown or cone, but the pyramid and cone demand a culminating form, thus the stem with the bud, flower and crest.

Hence it is a need of an antiquity unknown to us, for the carpenters to place the bush on the ridge of the completed frame of the roof, the cresting as a true acroteria, thereby indicating the time of completion. Now the varied forms of points and gable crownings of Gothic art, what are they other than permanent indications of that time, then the crest in the stone style. In spite of the so common designation of these crownings as crossflowers, the cross has nothing to do with them, and it is found far more frequently even placed above them, usually standing where the ancients had placed a cross, which they could and did publicly, and in fact had in a sense excluded a completion.

Projection of the crowning.

Now returning to our Fig. 1063, there is determined as we have seen, the side c d as the dimension of the ashlar and as the pr-

projection of the crowning. We do not maintain that this proportion as well as all determinations of the details should follow the dimensions of the stone with mathematical accuracy, and just in this case the reason for exceeding the width c d will appear later. But from considering the dimensions of the stone result two points especially important for the form of the pinnacle.

1. That the magnitude of the crowning does not increase or diminish in exact proportion to the pinnacle, that rather a considerable size of the pinnacle requires a proportionally smaller crowning.

2. That certain projections of the pinnacle correspond to each other, since the projecting parts are inscribed in the form of bosses.

In regard to the point first mentioned we refer to the pinnacles of greater dimensions represented in Figs. 1068, 1072 to 1077 in contrast to those of Roriczer and the metal pinnacle given in Fig. 1070 from the tabernacle in S. Maria at Lübeck. As in Fig. 1068 the combination of several blocks requires a smaller dimension of the crowning, so in Fig. 1069 the low location of the joint a b above the gable terminal leads to an agreement of the crown with the thickness of the pyramid or body, and in Roriczer the form of the entire pinnacle of one stone leads to an agreement of the crown with the plinth, and generally with the greatest projection occurring on the pinnacle. But that in those rules of the masters is assumed the construction of the entire pinnacle of only one stone, occurs several times in Lacher. Page 144 states:- "And divide the same thickness of the stone into 16 parts; of the same parts make a square as large as the body of the pinnacle."

Thus in Fig. 1070 the art of metal working allows entire freedom from such restriction, and therefore a crown beyond any dimension of the pinnacle.

Without this flexibility of proportions would the actual dimensions become entirely obscure, and further in certain cases complete deformations would occur. Such would result from an attempt to construct a buttress according to that of the Friedberg church about as shown in Fig. 1074, a pinnacle developed after Roriczer's system, or one of the pinnacles given in Figs. 1068, 1072 to 1077 with a crown constructed according to this system, or in the converse sense by the application of the proportions

developed in Fig. 1068 from the form in Fig. 1067 b.

Yet we note here also, that likewise the different periods in relation to the projections, first those of the crowning were very heavy, and that in the earlier men certainly rightly gave preference to a smaller projection even on smaller pinnacles, as this is shown by a comparison of Roriczer's pinnacles with this from the Freiburg tower perhaps 150 years earlier (Fig. 1069).

Height of crowning.

The highest point of the knob can lie just at the apex of the pyramid (Figs. 1063, 1065, from the choir of the church at Gladbach) or by lower (Fig. 1068 du. In the last case even when it is quite condensed, it lends the pinnacle a slender and aspiring character (Fig. 1072). A termination of the crowning even below the apex of the pyramid on the contrary can only satisfy the eye if that is extremely slender in form as in the examples of Figs. 1070, 1071. Most commonly must the starting of the crowning be above the apex of the pyramid, especially if the latter has the form of a crossflower; then the apex of the pyramid usually coincides with an evident division of the height. Examples are g given by Fig. 1072, 1074, 1077, in regard to the upper finial (while the lower has a shortened point).

While on the finials and pinnacles of S. Chapelle at Paris (Fig. 1072), the proportions of the pyramid are about 1 : 3 1/2, those of the entire height of the crown are about 1 : 4, and the division point 3 normally at the top of the moulding of the stem, the finials and pinnacles of the Friedburg buttresses (Fig. 1074) in the pyramid itself, thus from a to b has the ratio 1 : 5, the point 4 gives the bottom of the moulding of the stem and the total height of the crowning is determined according to the diagonal of a side of the base.

As already stated concerning the crownings of the gables, in general is to be preferred the octagonal section of the knob to the square one, particularly in simple forms, and accordingly the stem is chamfered so that by means of dimensioning, the width of the chamfer becomes a regular side of the octagon under the knob. The transition to the rectangular angle is then effected either in the stem itself, or in the moulding joining this to the pyramid or in the latter (x in Fig. 1074).

Pyramid and body of pinnacle.

According to the simplest and easiest way, the pyramid is placed on the body above a horizontal cap terminating it, whereby either the base of the pyramid is determined by a projection of this moulding, which then has the effect of a member of the lower border (Fig. 1076), or the base of the pyramid coincides with that of the body, and therefore the cap projects above and below. (Fig. 1068).

In most cases a horizontal separation between pyramid and body is lessened, and an intersection of both is found by the arrangement of gable roofs on four sides of the pyramid, at the same time discharging the rainwater diagonally. In our Fig. 1068 the height of this gable is 1/4 the height of the pyramid.

Square pyramid. Leaf crockets.

The angles of the pyramid remain plain only in a very simple form (Fig. 1075) or they are treated with a projecting round. As a rule they are beset with little flowers, the so-called leaf crockets, which give the principal outlines a more definite expression, and at the same time by their number make the size of the pyramid more apparent. On the older works may also be recognized the execution of a fixed principla, whereby the number directly depends in the size of the pyramid, and the width and size of the crockets would be constant like the converse proportion, and thus there is a constant number and a proportion of the size of the crockets to those of the pyramid. As a rule the number of crockets varies from 7 to 12, but increases to 17 on the great shrines of the cathedral of Rheims, and the little pinnacles from the tomb of Ulrich von Lichtenberg in Strasburg minster even to 26, but on the contrary on certain great pinnacles on late French works it sinks to 3 or 4 (Fig.1071).

Equal sizes of crockets on pyramids of unequal heights are sometimes required by the connection of these together (as in Fig. 1077). Generally in the later time the number of crockets is reduced and their size increased.

For the divisions of them to correspond to the bed joints, w which must lie between the crockets, as a necessity of construction

As a rule the distances apart of the crockets equals that of the upper one from the moulding of the stem as assumed in Fig. 1068. But sometimes the last space is wider, and preferably so, if within it is made the transition of the stem into the octagon.

The projection of the crockets is generally reduced with an

increase in their number, yet there is found here no distanct relation. But on the character of the entire pyramid the closer or wider spacing exerts a great influence, as can first be proved by comparing Figs. 1069 and 1071. More details on the separate forms follows farther below. In Figs 1068 and 1068 b we assume the well known horn-like shape from the shape of the capital and enclose this by two incisions paaallel to the sides of the pyramid.

The crockets either grow directly out of the angles of the pyramid (as in Fig. 1068) or a continuity of them can be produced by ribs which strengthen the angles and either stop on that horizontal moulding or the intersecting gables, or are corbelled out above them. The mouldings are to be of simple form and consist of a round, that may also be strengthened by a ridge or by a rectangular fillet projecting from the surface of the pyramid. These ribs either unite under the moulding of the stem (as in Fig. 1072), or then turn out the end at a square corner as in Fig. 1068, in the first case the section of the pnramid beneath the stem moulding gives a ground form of the square, which is then surrounded concentrically by that moulding, so that either in the last is made the transition to the octagonal stem, or the stem retains the ground form of the pyramid (Fig. 1073). A connection of the crockets together also results in a converse sense, in that the octagonal form of the stem continues in the manner, that the sides of the octagon lying in the diagonal direction extend downward as chamfers in the same width on the angles of the pyramid (Fig. 1079), and either stop on the gables or t the lower crocket, or below pass into the rectangular form by a transition.

Polygonal pyramids.

Entirely different from these chamfered forms is the shape of the finial of an octagonal pyramid, to be preferred in greater dimensions. Here result eight equal angles and therefore likewise eight ribs adorned by crockets. However such forms rather belong to forms of towers, and therefore become particular transitions from the square to the octagon and find their explanations there. As preliminary we mention here only the very peculiar pinnacles of the Early Gothic period, in which each of the four different surfaces between the square and the octagon forms the half of the basis of a smaller pyramid of a pinnacle, which

in its other half grows with the great pyramid and will become free in the development of the height. Fig. 1077 exhibits such a form from the west front of the cathedral of Rheims. Here the surfaces of all pyramids extend to the extreme edge of the projection of the moulding, so that the rib accompanying the angle of the pyramid is corbelled out, or rather stops at the foot of the pyramid on a beast leaning outward. A further enrichment is sometimes formed by a gable, that lies before the middle surfaces of the great pyramid, and thus is flanked by the little pyramids.

Finials of cross-shaped form.

A very peculiar transformatio of the octagonal ground form of the pyramid into the cross form is shown in Fig. 1081 representing the pinnacle from the buttresses of the cathedral of Besancon. On the squares remaining below between the arms of the cross are again placed smaller pyramids, and as the plan in Fig. 1081 a shows, they are divided by a moulding projecting in the crockets, which terminates with the last crocket, so that the simple cross form remains above. Since this moulding entirely covers the front surface, then exists the need for dimensioning it upward, that again includes a proportional reduction of the crockets and their distances apart. The ground form of the cross then continues in the crowning in the way, that the fronts form heraldic lilies, whose contours are then wrought, so that a similar intersection arises as that between two gable roofs. The entire treatment brings with it, that the pyramid only has a stumpy expression, from which certainly results a squatty and heavy effect. If then it is not to be denied that here peculiarity dominates beauty, yet these forms of the earlw time are especially instructive, compared with those of the 14 th century controlled by the monotony of the pinnacle forms, in which men are accustomed to see the highest development. It may be that the forms of the latter period, with especially the types of Cologne cathedral afford unsurpassed models for all in smaller dimensions, then will everywhere be allowable to strive for greater diversity, where it concerns a development of them in greater dimensions. But the motives there lying as a basis are connected with the construction of the spires of towers, and therefore here we must refer to the Section of our work treating the latter.

Triangular pyramid.

Also the equilateral triangle can be taken as a basis for the pyramid, and then by chamfering the angles it first passes into the irregular hexagon. A particularly thoughtful solution of this kind is found on the pyramids of the pinnacles of the high altar of S. Elisabeth in Marburg, which rest on the gables terminating the body according to the ground form shown in perspective in Fig. 1080, so that the angles of the triangular pyramid are chamfered by the surfaces b c and c d in the direction of the sides of the regular hexagon, and the side surfaces of the pyramid assume a concave form. By means of the diminution of the pyramid then the chamfers combine higher at e, and there results the form of the regular hexagon continued in the stem.

The pyramid developed from the triangle first requires a similar ground form of the body, yet may also be connected in a different manner with the square or rectangular form of the latter. The side surfaces may then be ornamented by the frequently mentioned scale work as in Fig. 1072, in greater dimensions by tracery as in Fig. 1077, and finally the pyramids may also be perforated, for which Fig. 1088 presents the simplest motive.

Body of the pinnacle.

What concerns the body of the pinnacle is its mode of treatment, the method of terminating all above the buttress and to apply what is said concerning blind panels. For the proportions of the height were already given on p. 459 and 460 the determinations of Roriczer and of lacher, that certainly for greater dimensions and structural functions of the pinnacles would no longer remain usubla, but are to be developed from the latter. If a harmony of the ground areas of pyramid and body lies nearest, so that both separating horizontal or gable cross sections project above and below, it is evident on certain works, particularly of the early time, that to increase the expression of the loading thereby, so that the extreme edge of that moulding limits the base of the pyramid, as in Figs. 1076 and 1077. Conversely the effect will be lighter by reducing the base of the pyramid from that of the body, whereby the former may assume a slendered proportion of height even exceeding that of Roriczer. By such slender forms then, as already the case in Figs. 1067 and 1069, there is excluded the possibility of completing the pyramid, the stem of the crowning continues the diminution of

the latter in a changed direction, and therefore differs in the earlier examples as in Fig. 1069, still by the greater height and the contrast of its simple angles from the pyramids with their subject crockets; but this separation lessens in the degree that the crockets are spaced further apart, and so there results a transition to that pyramid of the pinnical chiefly peculiar to the French Late Gothic, which is beset by widely distant and strongly projecting basses, and is terminated by a simple knob (Fig. 1071).

Simplified and combined forms of pinnacles.

Simplified pinnacles.

Simplified forms of pinnacles result when on the capitals of the angle columns dividing the body, besides blind enclosing arches also the ribs of the angles of the pyramid and the beginnings of the gable cornice rest on them, or if the gable is replaced by a projecting moulding concentric with the arches, or finally, when the arches directly intersect the pyramid, and thus in their thickness establish the transition between the inclined surface of the latter and the vertical surface forming the ground of the blind panel (Fig. 1064).

Richer pinnacles.

Conversely result more complex forms, first according no the principle which lies at the ground of the spires of shrines at Rheims (Fig. 1077). First its form suffers the transition that the four angle pyramids are replaces by angle pinnacles, and thereby is made easier the placing them over the horizontal ending suppressing the gable. Thereby will further be avoided the need of crockets of equal size on the great central pyramid and the smaller ones of the angle pyramids, since thus no longer come into contact with each other. Yet there is not now found an accurate observance of the proportion of the crockets to the different sizes of the pyramids, but rather a middle course is followed. Then the middle pyramid is a regular or diagonally p placed octagon, the diagonal of a square, or one placed parallel to the body, and likewise the little angle pinnacles are parallel to the diagonal of the great one. The lower pinnacle in Fig. 1077 shows an example of this kind.

The termination of the body of the pinnacle may receive a richer form, if the horizontal terminal moulding either passes above the gable as in Fig. 1088, or intersects the gable at the

height of the crown of the arch. In both cases with greater dimensions this cornice can have a tracery balustrade and angle pinnacles rising above the latter, which either stand directly on the gables or on the horizontal cornice. The great pinnacle from the end of the choir of the cathedral in Paris exhibits such a form. In the later periods the buttress evermore tended to express verticalism more decidedly, therefore to place the angle pinnacles on the capitals of the angle columns, which were then added to the jamb columnsof the arched members. Acordingly the gable cornice intersects the angle pinnacles or extends on their bases, or if these are wanting, on the projection of the capital of the column, and then each side of the pinnacle shows the completely developed stem of the form of the window gable bordered by little pinnacles, hence a reproduction of the whole at a smaller scale.

This system of ornamenting the smaller parts with the tapered principal form is especially characteristic of the middle and later periods of Gothic art and includes the possibility of an endless multiplication, so far as for example those angle pinnacles could again be formed according to the scheme of the larger, etc., until the conditions of the execution put an end to the principal infinity.

The use of reproduction in the development of height then led to placing on the body of the first pinnacle a second of smaller cross section, on this a third, etc. only crowning the last by a pyramid. Also there results by a similar arrangement the transformation of the pyhamidal finial into a stepped form in a series of prismatic bodies, and a lessening of the difference between finial and body, thus also here again by the diversity only of increasing monotony. This would go one step farther, when such a compound pinnacle was set on a buttress, and the offsets of the buttress likewise received pinnacles of like form.

That such a sequence must be subject to certain laws in order not to lead to monstrosities, will come from the following consideration:- if we take Roriczer's proportions as a basis, the first body would have a height of 6 sides. Assuming that the side of the second was reduced about 1/6, this would be 5 sides of the first in height. Assuming the third to be again reduced by 1/6, then it would be 4 sides and the pyramid terminating it is 2 3/3 sides high, and hence the entire form would approximate

the ratio of 1 : 20 instead of Roriczer's very slender one of 1 : 13. By reducing the offsets 1/10, there would result for the same case the proportion of height of 1 : 22, and therefore an unlimited height according to the degree in which the sections of the bodies approach each other. Therefore either the offset of each successive division or the proportion of the height of the whole be controlled to limit that increase in height.

Hence in Lacher (Reichensperger, p. 144) is found concerning the form of such compound tabernacles (which this is) the decision, that the second tabernacle, i.e., the second body of the pinnacle is to be formed according to the second square of the first formed quadrature, whereby its side would be about 7/10 of the first one; likewise the third according to the third square. We now accordingly calculate the height of the entire form and this will have the proportion of 1 : 16.5. Here we have indeed taken Roriczer's proportions quite arbitrarily as a basis, since Lacher gives no determination of the heightof the whole. A development in height would be found as follows:- In Fig. 1082 let the rectangle a b c d be the body of the pinnacle, then we assume the proportion of the height that shall be the sum of t the parts placed on each other (for example that about a simple pinnacle finial measures 1 : 6), and construct accordingly the pyramid c d e, that includes the otherwise freely chosen separate offsets f g h i, k l m n, and thus also the pyramid m n e of the latter. Thereby results in each division a reversed proportion of this height to the breadth.

When the smaller offsets of the body of the pinnacle (like t the second in Fig. 1082) a reduced proportion is obtained, then by reproduction of the blind paneling or by the assumption of a polygonal section, this will be partially raised as in Fig. 1083 Thereby this scheme may be combined with the before mentioned insertion of the plans within each other by Lacher, that indeed of itself results by the diagonal position of the bodies of the pinnacle set on each other.

As in Fig. 1081 is found a cross shaped form of the finial i instead of octagonal, so occurs the cross form also in the offsets, and it can here exert an influence on the richness of the elevation, so far as thereby results the development of 4 pyramids, from which rises the crowning terminal pyramid.

Everything said here on the development from the square is

likewise true for that from the triangle.

Conncetion of the pinnacle with the buttress.

The pinnacle may form the termination or an offset of the buttress or by a greater height of the body man make the predominant part of the entire buttress.

Pinnacles above the roof cornice.

The first horizontal termination occurs if the pinnacle stands on the roof cornice broken around the buttress. Here the dimensions of both parts may accord, or the pinnacle may be reduced so much that on the increased projection of the cornice the gutter mentioned on p 457 may find a place. The pinnacle then appears in connection with the balustrade, or so that the beginning of the latter may be wrought on it (Fig. 1093), or the part of the balustrade is inserted in the body of the pinnacle in a way like the tracery in the window arch, or finally if the pinnacle projects farther so that the connecting walls of the balustrade join the rear side of the pinnacle. The entire proportion of the balustrade then first leads to determine the height of the body according to the height of the balustrade, whereby this in ordinary dimensions has about the proportion of 1 : 1, or that of the side to the diagonal of the square. According to the form that the pinnacle must have, either the cap of the balustrade is to be broken around it (Fig. 1068), or the top of it is to be taken as a base of the arch terminating the panel (Fig. 1085). From this determination of the height indeed are found variations toward both sides; thus on the pinnacles of the S. Chapelle in Paris the base of the gable is found beneath the cap crowning the balustrade, while on most later works the endeavor to carry the height of the pinnacle above that of the gables crowning t the windows, or at least to attain the same height first permits a slendered form of the body of the pinnacle, so that its termination is raised far above that cap of the balustrade, as on Cologne cathedral.

Pinnacle on the covering of the buttress.

But the placing of the pinnacle on the horizontal surface formed by the crowning cornice requires an approximate agreement of the size with that of the buttress. Greater freedom occurs if the buttress terminates with an actual roof, on which then the pinnacle is either set considerably reduced or diagonally, or is placed on an area differing in form (Fig. 1076), so that

the difference is formed by the roof. Richer forms further result by the combination of the middle pinnacle with smaller angle pinnacles set on that difference in area. Thus on the choir buttresses of S. Ouen in Rouen, octagonal middle piers with two smaller angle pinnacles are set on the front side, a and on the latter on account of its smaller size, the pyramid is replaced by a simple low pyramidal roof. Preferable are the buttresses of the upper octagonal story of the tower, that afford opportunity for the same arrangement. So the buttresses in form of a diagonal square on the Freiburg tower, one is set on the diagonal middle pinnacle with 3 angle pinnacles, one of them is over the angle of the buttress, but the other two stand on the cap of the balustrade, while the fourth inside is omitted.

Further the pinnacles of the cap of the buttress beneath the roof cornice stand as in Fig. 1076, or already appear with the body in combination with the latter, as on the church at Friedberg (Fig. 1074). For smaller dimensions it is next to place the pinnacle at the point of application of the vault thrust on the offset of the buttress, whereby its body can always reach the height of the cap of the balustrade, that accordigly acquires an important proportion of height exceediug that of the pyramid. Thus the pinnacle can either stand free and connect with the roof cornice and the balustrade only by the spout, or even with the wall by a thin wall.

Pinnacle on an offset of the buttress.

The offsets of the buttress can receive pinnacles in the same way as the upper caps, or these may be made with a compound form of pinnacle, which then in a richer form already begins above the cap moulding and forms the predominant part of the buttress. This overrich form is chiefly peculiar to the later periods of Gothic art, and then by the use of placing diagonally, by artificial penetrations, by combination of solid with hollow pinnacles, i.e., shrines and figures, by the use of canopies and of the pedestals usually supporting the figures, quite charming forms are designed. Particularly in upper Saxony, on the choir of the church at Freiburg-on-Unstrut, on the city church at Naumburg, are found such forms. Yet it is to be noted, that even the accessories mentioned, the use of figures, the alternation of solid with hollow forms, etc., is here entirely necessary for good effect, and that the mere combinations of pinnacles, were they arranged according to

such an artificial scheme, yet easily produce a certain dryness, and that particularly by an excessive division of such forms of terminal pinnacles is easily caused an apparent vanishing, indeed in such a striking manner, if between the buttresses and the windows remain considerable wall surfaces. Really there is not easily found a more striking contrast, than that between the effect of these later works and those of the Early Gothic even if richly adorned, on which the entirely simple buttresses, and rich and graceful forms of windows, in which the wall surface dissolves, included between them.

5. Gables and Window Gables.

Coping and crowning the gables.

The simplest covering of the gable occurs when the roof covering extends over the gable wall, so that as for a wooden gable, the thickness of the tiles or slabes laid on each other forms the upper termination of the gable wall, and makes a small projection for its front face. But these projecting edges are exposed to the effect of the wind in a high degree, by which may be caused the raising and tearing away of some pieces. For protection from these effects, to shelter the roof from the wind, there is found on carefully executed works an extension of the gable wall above the junction of the roof, which as a rule is effected by a pediment with a coping at top.

Development of the edge of the gable.

Further to protect the junction of the roof at the inner side of this raised coping, thus the joint from the penetration of rainwater, every coping has here an undercut profile, a cut drip beneath which the covering of the roof lies, rising a little toward the coping. Fig. 1034 shows such a gable, where the upper moulding with its drip rises a little above the surface of the roof and forms a wind protection or gable, as shown by the cross section a b in Fig. 1034 a. 'Besides the proper name of "wimperge" is common that of "wimperg"; both names are employed for the coping and also for the little gable, especially when built over the window arch).

The separate cut stones of the coping stand best if bonded with the gable masonry, whereby according to the inclination of the gable and the nature of the stone, the bed joints are made horizontal as in the left half of Fig. 1034, or are perpendicular to the line of the gable as in the right half.

The thickness a b in Fig. 1084 a under the projecting coping must only be sufficient to afford a secure bearing of the separate stones on the gable wall, and need not agree with that of the wall, while a part of the latter extends under the roof covering, indeed so that for greater thickness a rafter lies on it. Richer arrangements result when on this excess in the thickness of the gable wall are formed steps leading to the highest point of the gable, and forming a communication between the two eaves of the roof. In this case the steps lie so much above the roof surface, that this drip x can be cut in t their lower edges, and the stairs is made safe by a parapet o outside, which either man take the form of a tracery balustrade, as on the church of S. Lorenz in Nuremburg, on the city hall at Louvain, etc., or the simpler form of the window gable.

If we now return to Fig. 1084 a, then the width a b also expresses at top the surface forming the back of the gable, so that the washes only extend on the projecting cap (Fig. 1084 b), or may be entirely omitted (Fig. 1084 c), or finally as in Fig. 1084 a the washes extend from both edges for the entire width and meet in an angle at the middle, which with a steeper inclination of the wash results a strengthening of the ridge of the gable. Fig. 1084 d shows the elevation and Fig. 1084 e is the plan of a stone of the coping.

Crockets and stepped gable.

From the originally rectangular shape of the block a b c d results the motive of the crocket projecting from the edge of the coping, just as it gives opportunity for the form of stepped gable more commonly occurring on works of secular architecture. Accordingly with equal sizes of the blocks each one has a crocket or forms a step. Gables of the last kind are now f found in different places. Thus as the latter motive developed from the origin leads to the arrangement of larger steps consisting of several ashlars, so the endeavor for freedom from the restriction caused by the size of the stones led to inserting the crockets in the back of the coping, or to form them with tongue and groove as in Fig. 1085 c. But nowise was the form of the crockets in the mass of the ashlars entirely supplanted by the last construction.

Crowning the gable.

The crockets extend to the middle so form the stem of the

Crowning of the gable, so that with the rib connecting the crockets either strikes the middle of the stem, or rises upward in the last two crockets; accordingly it lies close to the stem, and like the corresponding part of the rib itself, and if the former is inserted in the length of the side of the gable, must still be made in the same stone with the stem, which then receives tha form given in Fig. 084 f. From the size of this ashlar and the width m n accordingly results the determination of the magnitude of the crowning, that canno be in direct proportion to the size of the gable. If the breadth m n is too large, then the projection of the crowning is better determined by the thickness of the gable, thus according to the width x in Fig. 1084 a. Then if it appears preferable in certain cases to increase the importance of the crowning with the size of the gable, it is in the nature of the matter more suitable to seek this by an increase in height, by the choice of the form within those limiting projectiins than by an excessive projection.

Such massive crownings result from placing a simple finial on the apex of the gable, as on the portal of the north transept of the cathedral in Chalons, where the body is further indicated also by the four gables terminating it, or passes to a more complete development and thereby may receive a superior treatment and a greater thickness, that corresponds to the entire thickness of the gable wall, and therefore projects into the roof over the inner side of the gable.

Greater heights of the crowning further result from their connection with figures or animal forms, which either may be placed on the moulding or the stem or on its terminal knob.

Gable cross.

Greater projections are easily possible, when sought in mere development of width, and lead to the form of crowning by a s slab, and hence first to the form of the crowning cross. But before all the latter requires a certain size, which increases with the base of the gable, even if not in direct proportion to it.

We cannot here refer to measures of mediaeval works but only to modern experiments, and accordingly state that on a gable with a base of 8~ ft. a cross measuring 7 ft. from point to p point is entirely a mistake, while another of 3 7/8 ft over a

base of 24 ft. produces a sufficient effect. Thus in general it is a peculiar appearance with a vertical stem, that develops to a slightly projecting form of crowning, will give a suggestive proportion by the addition of a horizal bar becomes p puerile. Further it is to be considered in the form of the cross, that the horizontal bar seems larger at the height than the v vertical one, and hence requires a reduction in comparison with the size of the latter. This reduction then occurs by a tapering of the vertical stem upwards, so that the horizontal shall have the same size as the former at the intersection and also tapers to its ends.

Accordingly for greater dimensions the required length of the arms of the cross may exceed the dimensions to be obtained from one slab. In the case there remains the combination of three stone beams, so that the horizontal bar balances on the lower arm of the cross and the upper arm is set thereon. The same construction may also be employed on the so-called crossflower, and there leads to the form of a leaf cross from a slab lying on the stem, or of two overlapping stone bars. The entirely engaged character of this construction is quite foreign to the nature of the stone and plainly shows, that it is better to avoid all forms requiring it. The stem of the crowning then goes with the gable cap on the ridge, either with a penetration, oh it there occurs a transition of the ground forms into each other. Fig. 1050 a, b, ehibits an arrangement of this kind.

Pinnacles with stepped gables.

Just as pinnacles produce the crownings of gables, so also the angle flowers may replace them, when there remain additions from the mass of the ashlars. Here appears the analogy with the before mentioned form of greater gable steps. Sumh arrangements are even found on greater gables, as on the western one of the Teyn church in Prague, as well as on portal gables. We mention here the west portal of the cathedrals of Strasburg and of Cologne, and of the collegiate church at Colmar. On the work first mentioned is obtained thereby a greater magnipicence, that the pinnacles alternate with figures standing on low small columns. Yet it cannot be denied, that first of all the crockets closely set strengthen the impression of the gable slopes, such positions of pinnacles go beyond this and lead the effect into that of vertical developments. Thus the expression of the

inclination of the gable entirely disappears when the pinnacles extend down over the surface of the triangular gable, so that the latter seems lost in a certain number of adjacent panels crowned by ornamenta, gables, all of a predominant vertical character.

Beginnings of gables.

In regard to the relations which the gable coping at the lower ends of the gable have to the horizontal cornice of the longer sides, there applies substantially everything said of the gables of buttresses (Figs. 1037 to 1049). Meantime some modifications can be permitted by the special conditions. In Fig. 1084 c d is the line of the roof, and the profile of the gutter at its base is indicated by dotted lines. Accordingly the latter as well as the roof cornice in the front view of the gable either shows its profile as in the left half of the Fig., or the gable wall in the thickness of the gable below the gutter projects on a corbel, and thereby that profile is concealed. But the horizontal course of the gable cap e f assumes a greater length, and the load in it lies higher, if the edge of the gutter has a balustrade, as in the right half of Fig. 1084 (also see Fig. 1084 g). This horizontal course of the gable cap is fulfilled also if the inclined gable cap, instead of being bonded with the wall, consists of ashlars laid on it with the further purpose if opposing and abutting all the thrusts of thens blocks. Fig. 1084 g shows the side elevation in which at a the gable cap shows its profile, and thus assumes the form of a gable of a buttress, therefore all stated above concerning the latter also finds its place here. From the simple gable crowning as shown by Fig. 1084 g may further be developed a complete pinnacle pyramid, and further also the part of the wall beneath it with blind panels in the form of the body of the pinnacle, or even be changed into the form of a [illegible]. Also the pinnacle may, or even the simpler form of crowning, be transferred from the angle to the middle of that horizontal length, and thereby would a more important size be required, since this would be in relation to the entire length and no longer to the little gable a in Fig. 1084 g. Yet more massive becomes the covering of the gable by placing an entire pinnacle on that horizontal piece of coping. But the most complete form results of the gable is flanked fy the pinnacles set on

the butteess or even by angle turrets.

Purpose and connections with the wall.

The sc extremely advantageous arrangement of the extension of the gable between fixed and independent buttresses termioating in pinnacles results of itself in the window gables characterizing the richer style of Gothic art. By Viollet-le-Duc the origin of this arrangement is explained by the necessity for aiding by loading, increasing the strength of the window arch, that had to resist the thrust of certain compartment courses extending from the crown. On the static importance importance of the window gable see p. 342. As an intermediate member might have the motive fulfilling the desired purpose in the nearest way, might be inserted here a strengthening of the window arch by a concentric arch turned between the buttresses, that for its special purpose required a separate covering, and indeed the gable form suited to that of the pointed arch. Also as shown by Fig. 1085, while the proper window arch a supports the upper wall with gutter and balustrade, so this strengthening arch b bears the thickness of the gable wall covered by the window gable, which may be constructed in a different way. As in Fig. 1085 a the section through the crown shows, the thickness of the wall stands as far as the u upper edge of the roof cornice in connection with the masonry erected on the proper window arch, so that the separate ashlars of the window gable are bonded, and hence the block c in Fig. 1085 receives the shape represented in perspective in Fig. 1 085 b. Above the roof cornice the gable wall and balustrade then stand beside each other without connection, as shown by the section in Fig. 1085 a.

Conducting the water.

But by this mode of arrangement the removal of the water falling on the projection of the window gable, and therefore either the continuation of its wash to the face of the wall, or the arrangement of a gutter on its back is required. The first design is to be assumed about in the form shown in Fig. 1085 g, while the latter is generally followed as seen by the section on x y in Fig. 1085, shown in perspective in Fig.1085 d. At the base of the window gable, where it rests on the buttress is then found a gargoyle, that is connected with the channel.

Crockets.

In Fig. 1085 we have the working of the crockets assumed in the blocks of the window gable. The restrictions resulting from such a construction concerning the arrangement of the bed joints consist in this, that those resulting from the form of the roof cornice also pass through the window gable, and on the latter a crocket is formed on each block, indeed can be avoided by a more complex form of the separate blocks, most easily by an insertion of the tongue of the crocket in the back of the window gable as shown in Fig. 1085 c. This free position of the edge flower then affords the further advantage of facilitating the replacing of those injured by new noes.

Perforated window gables.

For a more animated and clearer form of the entire arrangement is further of great importance a perforation of the gable wall, as shown in Fig. 1085 at g. But also here in reference to bonding with the wall and the gutter lying at the base of the roof, as well as particularly the stonecutting in general, certain precautions are to be found, and first of all to avoid end joints lying in the face of the wall. A form suited to Fig. 1085 for the ashlars g and h is represented in Figs. 1085 e and f. But this changes according to the length of the perforation. If the last lies higher, then would the ashlar with the channel either extend through the entire thickness of the gable or an end joint could be placed within the perforation. But if the perforation were omitted, then would it suffice to let the stone of the channel a short distance into the thickness of the gable.

A further extension of this isolation then leads to making the gables and their crowning window gables entirely free before the masonry at the back of that projecting gable, so that there still remains space for the water channel behind, which accordingly instead of following the line of the gable as in Fig. 1085, has a course concentric with the window arch between the face of the wall and the gable wall. But this isolation of the gable wall leads further to its complete opening in a tracery scheme. Thereby in constructive respects it differs no more from the form of the tracery of the upper window arch, and joins the separate blocks of the window gable just as the latter those of the window arch; behind the gable then extends through the roof cornice with the balustrade and becomes visi-

visible through the openings.

This construction occurring at Cologne cathedral requires greater dimensions, and in smalles ones where it is already d difficult to obtain room for the beams and the channel with balustrade requiring a constant breadth, demands an exaggerated projection of the window arch. There is sometimes found a combination of the roof cor nice with the tracery filling the gable, so that the latter directly joins the face of the wall, the roof cornice intersects it and a part of the members of the window gable, and thus divides the tracery form of gable.

But thereby that transformation of the entire design is entirely justified, which is found on the choir of the church S. Maria in Mühlhausen, and consists on this, that the triangular gable is entirely formed of open tracery, rests on the roof cornice and replaces the balustrade.

Inclination of the gable.

The proportions of the inclination are still relatively low in the older examples and the entire height is small. On the window gables of S. Chapelle the ratio of base to height is a about as the side of the square to its half diagonal, and only the crowning rises above the edge of the gallery. With the lesser width of some gables, such as occur on the choir polygon, it was next to assume steeper inclinations, which usually predominate in Germany, so that about the ratio of 1 : 1 results. Generally the pinnacle rises from the apex of the crown of the window gable.

Ornamental gable of the tabernacle.

In the measure that the thickness of the gable wall diminishes, the originally structural importance of the window gable is lessened, is expressed only in the parts rising above the horizontal termination of the wall, and it disappears entirely when its entire height joins the vertical face of a wall. Then it can still strengthen it about like projecting tracery, and yet especially attains ornamental importance and becomes a simple form of crowning or of subdivision. In this sense it finds a particularly common use on the simpler tabernacles and repositories, that from the 1 th century onward in structural and formal respects in Germany at least exhibit an almost general type. As a rule this consists of a sill, two jambs and the covering, that is usually composed of a tall angulas slab set

on edge. Fig. 1086 shows such a tabernacle from the church in Frankenberg.

The sill starts with a corbelled moulding a either cut oll abruptly or returned at the ends, before the face of the wall with a wash above on which are wrought the starts of both the jamb members as well as of the angle buttresses set either square or diagonally. On the jambs occupying the height of the case is then wrought the member b as well as the buttress c.

In that tall and angular slab are continued the buttresses and the end in pinnacles, the jamb members combining in pointed arches, but the space for the case ends horizontally, so that in richer forms results a tympanum with foliage or figures. The arch is then crowned by a window gable which ends at the buttresses, so that the pinnacles start close above its ends. Above the window gable is usually a horizontal terminal cornice with battlements, either cut in the same slab or laid thereon, whose projection corresponds to the extreme end of the buttresses or is somewhat less, beneath which extend the crownings of the window gable and pinnacles, so that thereby is prescribed the same height also given by Roriczer. Thus the window gable is divided into three parts above the arch, that can be adorned in various ways. The working of the entire design in one stone thus permits the harmony of several projections, as with the crowning od the window gable with the pinnacle moulding, further a fertain moderation in the projection of the window gable, whose profile either directly joins the wash or a short horizontal part of the upper wall surface, and mainly leads to a form chiefly in the character of that given by Roriczer in Fig. 1067.

Different forms.

The exceptional character of the loading is thus also given always to the pinnacle in later works, in that this first rests above the junction with the window gable, an arrangement found in Fig. 1087, and also much later is expressed in even the smallest dimensions, so that as in Fig. 1126 the body of the pinnacle is still divided by a moulding on which rests the window gable. But it is lost in the mass when the junction of the window gable is placed higher, as by Roriczer on the base of the pinnacle, and almost entirely disappears when the pinnacle stands on the ground line of the arch, so that the window gable

penetrates its body. Thereby is connected also the replacing of the buttress by a little column or by a corbel, as may occur on a blind arcade crowned by a window gable. Yet with the last arrangement is again compatible the division of the body of the pinnacle by a moulding or the placing of the pinnacle on the intersecting window gable, as well as especially in smaller dimensions the pinnacles are omitted and the window gables rest on a corbelling.

From these different forms now come very varied proportions of window gables and pinnacles greatly differing from Roriczer's, as evidend by a comparison of the latter with the forms just described and also with those on p. 460 executed according to Lacher's principles. But the most striking contrast to Fig. 1067 is presented by the window gables from the tower buttresses of Cologne cathedral represented in Fig. 1037 from "Facsimiles of the original Sketches", as then generally an elegance of form is peculiar to all parts of the latter, which represents them al unequalled models, when already the earlier works and especially the French usually exhibit greater freedom of development. As an example of the latter kind, we give in Fig. 1038 a window gable from the tower buttresses of the cathedral at Rheims.

Recessed window gables.

Also the outline of the window gable suffers essential modifications in the later periods of Gothic art. Thus is first mentioned the crowning of that mentioned on p. 352, the mouldings concentric with the arch with stem and flower by means of a bending of the beginning of the junction of the stem to the form of the recurved window gable, which represents Roriczer's construction in its full development (Fig. 1067), and that can assume the most varied proportions of height, first in reference to Fig. 1067 according to the height of the point x at the apex of the arch, and further according to the form of the arch itself. By a lower form of the latter, i.e., that of the semicircle, then either with an unchanged height of the whole would result a predominance of the reverse curve over the arch (Fig. 1039), or a lesser height of the whole. But the latter would be still farther reduced by the assumption of a segmental arch or by the construction of the recurved arch by four points connected together as in Fig. 1090, such as produces that form of

covering the window frequently occurring in France in the Late Gothic.

This flexibility of proportions is however peculiar to the earlier forms of window gable in no less degree, for aside from the smaller size of the gable common to the older French w works, there also result moties from Fig. 1091, that make possible the retaining of any height. This Fig. shows a window gable over a segmental arch.

That predominance of the recurved arch over the arch itself is evident in Fig. 1089, and finally leads to the omission of the latter (Fig. 1092), and the pressure for ever novel changes in form to the compound shapes represented in Figs. 1092 a, b.

Intersecting window gables.

However even this motley diversity did not satisfy the masters of the later period. Men permitted the window gables to intersect, and finally even abandoned the vertical plane, when above an arched base line or the two sides of a triangle t they bent it outward, allowed the recurved window gable to be divided,and each half to continue farther in a recurve t the beginning of line of the recurved arch, and they finally even likewise carried the pinnacles also in these capricious ways, at last even passed from these still architecturally treatid to the freer forms of branches of foliage. We lack space here to go farther into this far reaching principle of Gothic construction, with the means of forms executed in a surprisingly artificial manner. These are generally termed affectations. Now one needs not to be warned from an imitation of these affectations, they are at the present time mostly opposed by the need of manual perfection, such as developed from the preceding centuries of Gothic practice, predominating for the time but not easily obtained. And thus also the perfection of technics all ensure to these degenerates of Gothic art a place in the history of art, that is still placed far above most modern art figures, designed in the present style and executed in cement or in similar substitutes.

6. Crownings and Crockets of Pinnacles and Window Gables.

Knobs and crossflowers.

Terminal knobs.

The simplest crowning form is shaped about like Fig. 1093, the stem with the knob first varies by a complex form of plan, for example by a concave shape of the polygonal sides or by the transition to the corresponding star shape of foil plans. These conditions of plan also make themselves felt in the elevation by the varied projections from the polygonal stems and the accurately resulting profiles. Thus Figs. 1094 to 1094 b exhibit a knob like a torus with hollowed sides, in whose section in Fig. 1094 b is visible the profile on a b and c d. A similar form likewise already peculiar to the Early Gothic period results from the mass of the knob, which is made diagonally, radially, or perpendicular to the sides of the polygon and indeed either as in Fig. 1099 a , may be through the angles or the middle of the sides, through both or between both. Figs. 1097 to 1099 show different stem mouldings formed in this way, which could also be used as crowning forms. Every cut is either left plain or filled by pearl beads, or there is found in it a slightly projecting member varying from that of the knob. There then the external surfaces of the projecting parts are usually divided by flutes in concave or convex shape, as Fig. 1099 a shows in plan, so that a similarity to certain kinds of gourds results.

The original profile of the knob, that shows a round or a lenticular member, is usually separated from the stem by a subordinate intermediate moulding or it ends above in a point (Fig. 1095 a), thereby obtaining a more bud-like and more or less compound form, (Fig. 1095 b, c), whereby however certain parts of the surface may be ornamented by flutes or any surface ornament like scales. On later works the bud form passes into the bulbous and pointed shape, or is cut off at top (Fig. 1095 d), or is replaced by a drip with flat or concave wash (Fig. 1095 e). The bud for richer development will be clearly expressed by the enclosing and either cosed or opened leaves (Fig. 1102).

Crossflowers.

Richer and more projecting forms then result by the arrangement of several, first of 4 arms extending from the stem, that again terminate in simple or compound forms of knobs. Such shapes which are commonly comprised under the name of crossflowers, are allied to those earlier forms of capitals contained in Figs.

456 to 480, as then the term "capital" nowise includes the conception of support.

Thus the astragal of the stem moulding, those volutes supporting the edge of the bell swing freely outward, and the bell itself becomes the stem and the abacus the terminal knob. In this sense the before mentioned form of capital would easily be transformed into a crowning, and would first require a more slender ornamental form. In Fig. 1100 we attempt such a development, about from the form of capital represented in Fig. 480. There the extreme square a b seen in the plan of Fig. 1100 a determines the projections of the four arms, the square c d e those of the lower row of leaves, the octagon formed of it, those of the stem moulding, and the square h f g in the s same sense the lower ground form of the stem. Likewise are developed the heights in elevation from the inserted squares harmonizing with the square a b of the plan, whereby the distance a i corresponds to the distance lettered the same on the plan, and the line ik thus given limits the thickness of the terminal knob and that of the buds.

As in Fig. 1100 the volutes forming the upper circle project beyond the leaves of the lower row, then is the converse proportion usual, whereby the projection of the lower row exceeds that of the upper, or that more important development in height, the upper exceeds about so that the successive squares of the quadrature give the sizes on the plan for the different rows in the given sequence. According to this system is constructed the crowning flower represented in Fig. 1096, and therein is given the development from the plan by the similar lettering. There the heights of the separate rows, thus 11, 22, 33, are determined by the sides of the corresponding squares of t the plan. A substantial modification is suffered in the character of the whole by the different proportions of the heights, which could vary on both sides from those here given, so that as in Fig. 1097 even the heights could be determined by the diagonals of the squares concerned or conversely, or as in Fig. 1097 a by the half diagonals. Likewise the proportionality of the heights of the plan dimensions nowise forms the general rule, but on the contrary the heights are usually ejual to each other.

In Fig. 1096 the plan division of the stem moulding is deter-

determined by the octagon formed on the outside square. The m resulting bold form is first of all peculiar to French works, on which a richer form of this moulding predominates, even to the degree that it dominates the row of leaves (Fig. 1101)and the whole becomes similar to the form of the bud.

The vertical direction attains to a more decided expression not only by an increased height of the separate parts, but also by an increase of their number (Fig. 1097), whereby the form approaches that of a stem with beginnings of leaves.

If this arrangement is already predominant, whereby the square of the lower row is set diagonally and the succeeding squares are diagonal to each other, then there is no rule in this, and likewise retaining the diagonal position to each other, the parallel position of the lower square is the parallel position of the squares to each other.

Further modifications of the form of plan result by the arrangement of 8 arms as in Fig. 1098, or by the more rarely occurring 6 on the hexagonal, or of three on the triangular stem. Still as a rule a hexagonal plan of the buttress or of the stem is connected with the square crowning, so that two arms project from the surfaces and two from the angles of the stem.

Formation of the arms.

In the earlier time the branches of the crossflower mostly have the shape of extending volutes or of boldly bending stems, which at their ends bear a bunch of leaves corled downward. (Left half of Fig. 1096). Later predominate those also occasionally found in very early times, forms of leaves ascending upward, that usually grow directly from the main stem (right half of Fig. 1096).

The simple line of projection seen in the right half of Fig. 1096 suffers the next modification by an increased bending of the ends of the leaves (Fig. 1099), which again as in Fig. 1112 leads the ends into a form like a ball, whereby may occur a deflection of the line connected may occur, so that the entire effect is again almost allied to that of the volutes. The transformation of the latter is still more expressed in Fig. 1104, in which the leaves have greater importance and decidedly swing upward instead of downward, while the arms on which they rest form an angle with the stem. These leaves are derived from the form of bud shown in Fig. 1102; from it by the opening of the

leaves to that of Fig. 1103, and thus farther by the combination of the different motives so far represented to the forms illustrated in Figs. 1106 and 1105, the first of which with an ever ascinding main line yet already shows some complex bends, and so permits the transition to the later forms.

Later forms.

For the later time therefore besides a more horizontal line of projection, there is an increased number of forms of bends with short breaks as a characteristic, about as Fig. 1105 shows, but soon the line of projection becomes a strongly recurved and again a sinkgin one, the bends are stronger and more swelled, and the separate parts of the leaves are animated by those spherical swellings (Fig. 1067b), that we have already mentioned on the leaves of capitals. On other leaves of the same period occur those exaggerations in a less striking way, and there result very bold and beautiful forms. Such an example from the upper terrace of the tower of Strasburg minster is shown by Fig. 1115 b. These swelled forms then follow certain predominant geometric ones, of which we give an example in Fig. 1103 from the upper balustrade of the tower at Freiberg, whose execution strongly contrasts with that of the greatest part of the foliage found there, and it is no longer to be attributed to the date of the erection of the spire. Besides the before mentioned diversities in the proportions of the stylistic keeping are to be seen certain marks more related to the main forms of the separate arms.

1. The form of plan of the entire series varies between the cross, that is expressed in the forms represented in Figs. 1096 and 1099, and the circle that rather dominates Fig. 1107. Between then then lie the forms of the quatrefoil and that of the square, which are more peculiar to the later feriod.(Flower contained in Fig. 1077).

2. The line of the upper termination is either ascending or horizontal, so that retaining the same form of plan and line of projection, there results the difference in the forms of bosses for the different parts as shown in the two halves of Fig. 1110.

3. The profile is either wrought in a direction parallel to the upper ending over the entire part, or is changed in the different parts of the leaves. According to the first mode of

treatment (Fig. 1109) the effect becomes more quiet and recognizable at greater distances, and this is found both in the f flowers of the earlier period as in those more folded ones of the later time(Fig. 1105). But it is only to be understood, t that the principal lines of certion parts of the leaves lie in the surfaces of the simple form of boss, and further modeling cuts it. The second mode of treatment expresses itself most c clearly in these projecting bends of Late Gothic foliage, and is already found employed in Early Gothic on certain parts of the leaves.

4. The direction in which the separate leaves or parts of leaves grow is either one away from the stem, or one recurved from the point of greatest projection. Figs. 1105 and 1104 exhibit these different motives. The first has the leaves attached to the underside of the volute supports already on the form of capital represented in Fig. 463, the second is to be referred to the different forms of the ending of the support.

The richness of these crowning forms can even be increased by combination with animal forms or figures, which crouch or stand on the stem and thus form its endings. Particularly beautiful examples of this kind are found on the buttresses of the side aisles of Strasburg minster. Fig. 1098 shows an example from the portal of the north transept of the church in Gelnhausen. Likewise such forms can replace the crowning as on the pinnacles of the choir of S. Ouen. (Fig. 1083).

Further as already mentioned for gables, the crowning may assume the form of a pinnacle or pyramid, as on the portal of the north transept of the cathedral of Chalons.

Conversely the pyramids may also be replaced by the ordinary forms of crowning, like the roof balustrade of the clearstory of the cathedral of Paris. The balustrades on the towers of the same work then exhibit a substitution of the pinnacles by animal figures, which stand inside the balustrade on its floor, and leaning over the parapet look out over it.

Crockets or angle flowers.

Crockets on the back of the coping.

Like the separate arms of the crowning from the stem, so start the crockets from the back of the window gable, and they can therefore pass for a continuation of the former, harmonizing with them in shape and size. This agreement can be complete

by adoption of motives of volute forms or of leaf forms derived therefrom, and may lead to the omission of the stem, and hence results the form shown in Fig. 1084 f. The continuity of the crockets with the arms of the crowning makes itself felt even with different size and shape, when the middle line of the crowning extends in that of the crockets, an arrangement which is contained in the window gable represented in Fig. 1085, but it also requires the profiling upward of the coping shown there, i.e., a considerable projection of it, and requires the termination with an edge or a rib connecting the crockets, as shown by Figs. 1111 and 1111a. In this case the crockets stand in a vertical plane, so that the cross section of a b recalls the form shown in Fig. 1111 a, and there can be employed all arms of the crowning shown in Figs. 1112 and 1114 as crockets.

Crockets on the wash.

In all these more ornamental forms of window gable mentioned on p. 474, which lie near the wall surface, where further the channel lying behind them is omitted, so that the wash is a short horizontal line on the wall surface (Fig. 1113 a), the vertical position of the crocket leads to a growth of it with the wall. Thereby the ending of the leaf always rising from the upper edge of the profile of the window gable receives a bend forward, so that the surface of the wash is covered by it. This arrangement is found on the crocket in Figs. 1113 and 1113 a, from the wall tabernacle of the church in Friedberg. This further leads to extend the starting point of the leaf from the upper edge down on the surface of the wash, and to change the line of its movement from the vertical plane to one more inclined and perpendicular to the line of the wash. Hence results the peculiarity that the leaf now exhibits its surface development, instead of this profile in the front view as in Fig. 1111. Figs. 1115 and 1115 a show such crockets from the upper story of the square of the south tower of Strasburg minster.

By this varied position is further given the possibility of a freer treatment as proved by Figs. 1116 and 1116 a from the south portal of the Franciscan church in Fritzlar.

But there remains predominant until the last period of Gothic art the retaining of the motive resulting from one arm of the crowning in combination with a nearly perpendicular position

of the line of the wash, whereby the points of the leaves of the averted side remain visible over the line of movement of the whole, even when the edge of the window gable forms the starting line. Fig. 1117 shows such a crocket, that is seen sidewise in Fig. 1117 a and in Figs. 1117 b, c, is projected at 45°. It is at the same time peculiar to the later period, from the mode of drawing peculiar to it is visible the inclination to perspective representation, that is also expressed h here. Care was taken since something of the effect of the leaf might be lost.

Differing forms.

The taste for ascending curves, which characterized the later period, also then led to a modification of the line of movement, whereby the leaf or crocket, instead of rising in the direction of the window gable, rests thereon by a later bend in a horizontal direction, and this from an attached part becomes an addition laid on it. This conception is most clearly expressed in those forms, that show the beginning of the leaf uncoiling from a short branch cut off at both sides and lying on the wash. (Figs. 1118, 1118 a). Indeed scarcely is needed a reference to the advantage of the earlier form developing itself from the members of the coping, and the effect of the angle flower strengthening it for the later, thereby completing and in a sense resisting.

The crockets sometimes project horizontally without regard to the inclination of the gable, and their effect is trailing in a way, but on account of their strength they were preferred to the before mentioned swollen buds. Fig. 1119 shows such an example from the gables of S. Vaudru in Mons.

Simplifications.

In smaller dimensions, as they first appeared on the pyramids of pinnacles, certain simplifications are necessary for the crockets, already expressed in the word "crockets"(Laubbossen) in Roriczer, that we have also retained for the richer forms on window gables. From "boss" it denotes the principal form, the body further detailed, which the stonecutter must work out of the rough mass before he proceeds to the latter.

Since now the closer detailing is arranged according to the actual size by its distance from the eye, in smaller size it is omotted and the bosses become the complete form, but this

is to be simplified in continued reduction. Thus Fig. 1120 represents the bosses on a leaf contained in Fig. 1106, or in Fig. 1120 a again the bosses in Fig. 1120 and both forms could appear as leaf bosses (crockets on pinnacles).

The same condition results for smaller dimensions of window gables, so that Fig. 1121 represents the bosses in Fig. 1117, which then by simple modeling receive the form given in Fig. 1121 a. Yet there is always found a tendency toward nature, to the motives of certain simpler forms of leaves instead, and F Fig. 1021 b shows a direct imitation of nature. But also here by retaining the older motive of the volute-like form as in Figs. 1085, 1088 is most easily found the measure of simplification and a stronger contour of the whole is obtained.

7. Canopies and Pedestals.

Canopies form protecting roofs over single figures, a continuous series of figures or reliefs, and therefore in smaller dimensions replace the before mentioned shrines, developing in their simplest forms from those represented in Figs. 1058 to 1060, so that the slab or tunnel vault is separated by corbels projecting from the wall instead of detached columns. An example of the last kind is found on the exterior of the cloister of the cathedral of Laon.

But in the degree that the dimensions permit the execution of the canopy in a simple stone, the corbel becomes superfluous, and it then assumes a typical form af a vault on a polygonal or round plan with suspendeng arch springings and vertical external walls, which then in the simplest way is covered by a horizontal simple or battlemented cornice with a graceful crowning in richer developments.

Treatment of additions.

The older and richer examples exhibit a certain relationship with the forms of those chandeliers, of which we find the most developed types in Hildesheim and Aix-la-Chapelle, and which consist of a horizontal circular hoop or one in quatrefoil shape in metal, which is beset by turrets, castles or other buildings at regular distauces. In Hildesheim this combination of buildings with entire decision passes into the representation of the heavenly Jerusalem. If it was next to conceive the chandelier as disseminating the heavenly light, and in this sense to adorn the city of God, then the canopy should replace the

nimbus or halo, whose representation was little suited to the means of sculpture. This relation very frequently leads to a certain harmony of treatment, that on certain particularly prominent examples goes to the intended representation of the same objects. On the contrary there appear on most an architectural treatment of the given motive effected with the greatest freedom and essentially differing from the form of all other parts. For it is here even the capricious element, which here where it only concerns the artistic form of a stone soaring o over the figure, and not the connection of it with others, thus being a real structure, makes effective in an overpowering degree, in like manner as this is also the case in the pointed architecture of the glass window.

Thus these additions above the horizontal or the termination of this vault by little gables mage by the most varied combinations of simpler or richer buildiggs and towers of one or more stories, that rise in one or several stories over each other. The plan of the single series is related to that of the vault about so, that over the middle of each polygonal side stands the building proper, over its angles rise the flanking turrets, and the second series is placed alternately on the plan of the lower one, and also well forms a simplification of it, but from the whole rises a massive tower in a sense as the citadel of the city, which serves as the pedestal of several figures placed above the upper one.

Suspended springings of the arches.

Thereby is expressed the ornamental character of the whole further in the reduction of the size of the suspended arch s springings, that are based only on the possibility of execution in stone and not according to the proportions required by an actual vault. These arch springings as a rule are then either cut off horizontally on the base line of the vault, or they are inclosed by a leaf form developed from the members. Figs. 1122 to 1124 exhibit such examples from the so-called angel's column in the south transept of the Strasburg minster, the north portal of the cathedral at Rheims, and the buttresses of the south side of the Freiburg minster. On such points that permit or require special accenting, are sometimes interwoven figure elements in the form of the canopy. An example from the west portal of the church at Volksmarsen is shown by Fig. 1125,

where the cross ribs of the canopy of the portal arch are held by two angles projecting from the mouldings of the arch, whose abutting wings form the side arches. A simpler arrangement of this kind is found in Viollet-le-Duc, Vol. IV, p. 437, where the angel rising from the shaft of the column with expanded w wings forms the canopy.

This freer mode of treatment is predominant untel the close of the 13 th century, es the west portal of Strasburg minster exhibits very charming forms of this kind, in which the most intimately developed system of pinnacles and window gables always makes itself more distinctly felt. But soon also reappears that freedom resulting from the nature of the matter, which makes itself known in the gracefulness of the ending arches. Their size simulates a structural need, and they are formed with greater ornament, so that the idea cannot suffer any manual awkwardness arising from its increased size; they rest on projecting and more or less compound corbels (Fig. 1126), or the pinnacles or buttresses flanking the angles extend down to the corbels, and the arches and gable mouldings intersect them. Accordingly results a polygonal form spanned by a cross vault as the type of canopy, so that very simply the columns are omitted and their capitals are changed into projecting corbels. In this sense can all arrangements given for the shrine and t the complex shapes of pinnacles also find employment here.

As already stated, canopies must protect the figures standing underneath on corbels, columns or piers, so that from them results a certain relation of their plans to those of the pedestal, which usually occurs so that the inner clear width of the canopy equals the external one of the pedestal. A harmony of the ground forms is usually found, yet without being rejuired by the nature of the matter.

The entire form is attached to a plane surface, an angle or a column.

Form before a plane surface.

In the fist case the canopy usually occurs in combination with a niche increasing its plan to the entire polygon (left half of Fig. 1127), so that half the springing of the arch rests on the little columns a and a′, or the niche is formed as a circular segment, so that rib 2 is omitted, or finally there remains standing only the little columns a, a, and they

are connected by a side arch. In the simplest case these columns are also omitted and the arch springings a rest directly on the wall. But it is then preferable to indicate the background of the figure for the breadth of the canopy by a pattern or at least by a colored coating.

The little columns a either stand on the outer edge of the pedestal, or if the plan of the latter does not suffice, or they are corbelled out above the pedestal.

Figure before an angle.

For a canopy before an angle, as a rule this is chamfered in the height between canopy and corbel.

Figure before a column.

Before a column or a round project the canopy and pedestal according to the earlier arrangement, so that certain headers form the column or round, while the figure is either wrought from a cylindrical block behind and standing on end, or both consist of two placed beside each other. Here then also the pedestal is sometimes carried down to the ground, a column being placed on it, and with the same it is wrought from one block.

As a rule on later works the part of the column or round for the height of the figure is omitted, so that either the lower part of the column terminates with a separate capital bearing the figure, or a projecting corbel is arranged for the latter, beneath whose upper edge the former stops (Fig. 1126 at a), while the part continuing above the canopy is either corbelled out above that (Fig. 1126 at b), or rests on it. It scarcely requires mention, how very much the earlier arrangement excels the later, the static function of the round by the interruption increasing in consequence.

As already stated above, the pedestals of the figures as corbels, columns or piers, that by their construction fulfil other functions, do not differ in general; certain peculiar forms c connected with forms of portals can only be investigated together with the latter.

We have already shown on p. 242 how for the understanding of the subject represented is usually aided by a legend placed on the corbel. The same explanation is also frequently found in a finer way by secondary figure representations concerned with the meaning of the whole either directly or by contrast. These are then interwoven in the ornamentation of the capital

or corbel, or on the portals of many French cathedrals, it takes the form of a low canopy, under whose vault the smaller f figures crouch and almost fill the space, or finally the representations in relief concerned are found on a low pedestal s set on the proper support of the figure.

Likewise the column in the position in question usually assumes a freer form, sharply accenting the more structural character of the round. In Fig. 1128 we give an example of this kind from the vestibule of the north transept op the cathedral at Chartres.

VIII. WINDOWS AND TRACERY.

1. The Window in General.

Development of the window.

Protected position of openings for light.

Before the general introduction of glazing the closing of openings for light was a kuestion, which decisively influenced not only the treatment of these openings but the entire form of the building. In order to create larger openings for the living and occupied rooms, that were protected from the inclemency of the weather and sheltered from the noise and dust of the outer world, men saw themselves compelled to place projecting roofs or porticos before the rooms, and to have the latter open on internal closed courts as much as possible. This opening of the rooms toward the interior finds its corresponding expression in the plan of the antique house, and was transferred to the cloister of the monastery in later centuries, but for the latter certainly were added further reasons for the separation from the external world.

Openings without closure.

But now such a protected position could not be assigned to all windows, and they must often be placed in the outer walls, very particularly in great and spacious monumental buildings. If this concerned subordinate openings for light and air, that perhaps led into rooms of less importance, then they were left entirely without closure, just like many windows in towers and gables at this day, or at most in special cases grilles or wo wooden shutters for occasional closure were placed before them. To prevent the entrance of rain as much as possible, such free openings are made relatively small, since then the greater thickness of the wall aids to protect. Instead of a great window, several small ones are placed beside each other, that in some cases are comprised by a common arch, their appearance having the expression of a single great window.

Transition to glazing.

The windows on great monumental buildings, to be left entirely open especially in churches, were not always required even in southern countries, and a temporary closing by shutters was difficult to execute for artistic and practical reasons, especially in high windows, and men must therefore devise a closure for admitting light and keeping out weather as far as possible,

that were found in the Byzantine period in perforated marble slabs often richly carved. (Whether and how far these already exhibited partly inserted pieces of glass must remain an open question). Since these slabs stopped much light, the window openings were not made too small, and only later when first in the 10 th and 11 th centuries they employed more and more the then very costly glazing with colored glass set in leads, these were reduced to the very least dimensions, so that even early large windows sometimes appear to have been reduced later.

In the sama degree that the manufacture of the glass was perfected and cheapened, could all window surfaces be increased, the more because at the same time the development of the system of support of the wall was more substituted in the place of the simple enclosure of the room, when men could freely open it w without injuring its durability. Thus in the beginning Gothic men were in position to develop at the greatest scale the glass area according to any practical or artistic requirements, which was done more willingly, because the ever more splendidly developed glass painting in the meantime supplied the charmingly effective ornamental decoration.

Glazing the window.

Size of the pieces of glass.

The size of the easily obtained pieces of plane glass was limited, they did not exceed in any direction much more than the length of the human hand. These pieces must be so joined that the joint allowed entrance of no air or water in an annoying manner, and as a suitable material was employed the very flexible lead, which until the beginning of our century maintained its unlimited importance for the making of window bars. Lead bars as shown in Figs. 1129 to 1129 b in nearly natural sixe in cross section have a middle web and two flanges, whose widths are between 3 and 7 mm. The bars are cast in moulds, and the drawn lead first came into use since the Renaissance, whose use is recognized by the impressions of toothed wheels on the web. Accroding to the cartoon fasterned on the working table are cut the pieces of glass, and then at a corner they are inserted in the grooves of the leads laid between them, which are easily bent and as far as possible are made in one piece; Where they abut against each other, the ends are cut off square or oblique with the knife anf soldered on both sides. In this

manner a panel of square, rectangular or any other shape is f formed to correspond to the portion of the tracery, and they it is enclosed by a common lead bar, or by one with a grrove on but one side (edge bar), although this lead inclosure of the panel is not always found on mediaeval works, it is well to make it.

Dimensions of panel. Saddle bars.

The breadth of the panels, on account of the necessary stiffness, cannot well exceed 60 to 100 cm, but usually amounts to only 50 to 75 cm, and for such panels one is also already compelled to place thin round (rarely angular) iron rods of 6 to 10 cm diameter, the so-called saddle bars (wind), that are fastened to the lead bars by lead strips wound around them and soldered to the lead bars. The iron bars are best placed in the shortest direction of the panel, but not to disturb free view, they may be oblique to the bars or be curved. The ends of the iron rods are usually hammered flat, that they may be fastened in the edge bar. For windows very strongly exposed to the wind, saddle bars more than 60 cm length by 20 to 30 cm apart must not be under 1 cm diameter, if they must prevent a bending or even a crushing of the panel, and particularly with valuable glass paintings must be used strong saddle bars near together, and the width of the panel should not be allowed much to exceed 60 cm. For windows little or not at all exposed to wind, these considerations do not apply, and thew need only s some thin iron bars, which preserve the plane surface of the panel.

Technics of glass painting.

On the technics of glass painting it may be briefly stated, that in the Romanesque and Early Gothic time was only known a single dark brown painting color, the black lead with which t the outlines, ribs and leaves and darker grounds of the ornaments were applied, but otherwise each color tone in even small areas must be inserted as a separate piece of glass. Great areas of the same color, that exceeded the dimensions of the glass, or their hooked form could not be cut out, were composed of several pieces by the aid of division (extra) leads. In the 14 th century appeared a new painting color, the artificial yellow, and further men began with red glass that was always flashed glass, sometimes ground off white; later was set glass

with other colors applied on one or both sides, and at the beginning of the middle ages men commenced to lay all colors after each other. These changes commencel at first by the use of too many dividing bars, and later by the changed tendency of taste; yet the more that the technics of painting was perfected on the one hand, on the other the more the architectural effect of the surface suffered damage.

Besides the many colored windows there occurred those windows painted only with black lead in hatchings (grisailles), with the use of scattered pieces of colored glass or even without them. Finally in consequence of the strict rules of orders (Cistercians), instead of windows in strong colors were commonly employed those of white glass set in lead patterns, few of which still remain.

Highest in their monumental effect must incontestability be the windows composed of deep tones in mosaic effect of the earlier period, that in their ornamental and figure representations always present an united rich but quiet picture suited to the surface. (See Schäfer and Rosstäuscher, Ornamental glass painting).

Dimensions of glazed windows.

Only for windows of very small size, little round windows or those subdivided by tracery, is it possible to close the entire opening by a single glass panel composed in the manner d described above, but as a rule the window requires the placing of several panels beside each other. If the panels are joined in height alone (Fig. 1130), the window can have only a clear width of 70 to 90 or at most 100 cm, but on the contrary if there is a division also in width (Figs. 1131, 1132), then the breadth of the window may increase to about 150 cm, thereby u usually reaching the limit. If it be necessary to open a wider area, then must several such windows be employed beside each other, that are either separated from each other by solid pier of wall or at least by stone mullions.

In the time about 1200, when a pressure for creating wide openings strongly occurred, but the tracery first began its development, there existed windows of more than 1 1/2 or indeed more than 2 m (Rheims, etc.), which were subdivided into a network of square panels by the use of strong iron bars.

Junction of glazing with jambs and mullions.

it now concerns the fastening of the separate panels of glass in the window, where they abutted against the jamb or the middle mullion, it was either slid into a groove (Fig. 1 13), whereby the panel necessarily was somewhat bent during the insertion, or the glass panel was laid against a rebate (Fig. 1134), that only required a width of . to 1 1/2 cm. On windows exposed to strong windu, the rebate faced outward, so that the window was set from the outside, and the putty was added on the exterior, and the wind pressed the window against the face of the rebate. Protected windows and those near the eye were also very frequently inserted from the inside. The rebate or the groove was caulked with lime and hair, recently mostly with putty or less well with cement.

Storm bars and cover bars.

The line of junction of two adjacent panels requires strengthening and ornamentation by a special arrangement. Here are placed strong iron bars 25 to 40 mm wide and 8 to 15 mm or more thick, that are called storm bars (Fig. 1135), whose ends are sunk 4 to 8 cm deep in the jamb or mullion, best being equally inserted in the masonry and firmly set in lead or otherwise so firmly fastened, that they cannot become loose. Less good is setting after erection, which is made possible by sinking a deeper hole and afterward drawing the bar out to enter the other end.

Storm bars must be set flush with the face of the rebate, so that the glass panel can rest all around. To hold and fix the glazing, the storm bar on its middle line at about 20 to 30 cm apart has projecting clamps, k in Fig. 1135 through which are driven little wedges or curved keys s after placing the panel. Instead of placing the key directly against the panel, it is better to place a cover bar (d in Fig. 1135). It has the same width as the storm bar with a thickness of only 3 to 5 mm and fits over the clamps with mortises, and by driving the keys the glazing is clamped between storm bar and cover bar. Clamps and cover bar are naturally on the same side as the glass panel, thus genérally being outside.

Already on wide windows (Figs. 1131, 1132) occur crossings of horizontal and vertical storm bars, and thus they appear yet more on round or tracery windows, where result divisions according to the mode in Figs. 1136 to 1136 b. On the so-called

foiled windows a storm bar generally extends around at the ends of the cusps (Fig. 1136 c). It is natural that the entire design of the window should be in harmony with the storm bars as much as possible, so that the latter may assume a rich arrangement, an example of which is offered by Fig. 1137 from the west front of the cathedral of Rheims.

At the crossings of the storm bars is a bend to avoid weakening the junction, as one must extend over the other (Fig. 1138), as the old works show.

One of the cover bars extends through at the intersections, while the other abuts at its ends, but the ends of these bars require no fastening at the jambs. In recent windows sometimes a narrow cover bar is carried around the entire perimeter of the window in order to press the glass panel against the stone rebate, but this is useless as a rule, for good puttying mostly suffices, and the wind bars ending at the jamb are fixed in little holes in the jamb or in the groove.

Dimensions of cross section of storm bars.

So that the storm bars may well resist the wind anf not bend too much, they must not be made too thin and their ends must be firmly fastened. A bar with movable ends breaks 1 1/2 times easier and bends 5 times as much as a fixed bar of the same cross section.

Assuming a wind pressure of 120 kil per sq. m and a permissible stress in the iron of 1000 kil per sq. cm, there are collected in the following Table the required dimensions of storm bars for different lengths and distances apart.

Sizes of storm bars.

Proper size and deflection d under wind of 120 kil per sq. m.

Span	Dist.	W.	Th.	d	W.	Th.	d	W.	Th.	d
cm.	cm.	mm	mm	mm	mm	mm	mm	mm	mm	mm
75	60	25	9	2.0	30	8	2.1	35	8	2.3
75	90	25	11	1.6	30	10	1.7	35	9	1.9
100	60	25	12	2.6	30	11	2.8	35	10	3.1
100	90	30	14	2.3	35	13	2.5	40	12	2.7
125	60	30	14	3.6	35	13	3.9	40	12	4.1
125	90	30	17	2.9	35	16	3.1	40	15	3.4
150	60	30	17	4.4	35	15	4.6	40	14	5.0
150	90	30	20	3.5	35	19	3.8	40	18	4.0

Note. The thickness is given in entire mm for fractions over 1/2

The tabular values again show a striking agreement with the experience of the ancients, are established for fixed ends, b but since these cannot be assumed with certainty, the thicknesses of the bars are to be increased about 1/5, so that the stress in the material remains the same; such a stronger bar with movable ends always still bends nearly three times as much as given for the fixed thinner bar in the Table.

Bars 125 to 150 cm long come in question only for windows w with vertical divisions (Figs. 1131, 1132), where so little is to be counted for the stiffening effect of the long vertical bars, that the transverse bars alone must be able to meet the wind pressure. For such great lengths in less severely historical buildings now, by utilizing the advances in our technics may also be employed T sections 3 1/2 to 5 cm wide, whose webs a b can be directly utilized for passing through the keys. (Fig. 1139). By bending the outer edge from a to a′ is formed a drip protecting the lower joint, or for the same purpose may be bent over the iron bar a strip of lead, copper or zinc, which at the same time protects from rust and could also form an internal channel for condensed water. But in general the construction of the middle ages is so well preserved, that it scarcely needs protection.

Window jambs and sills:

Form of jamb.

For openings without glazing, the wall has a simple rectangular jamb or one with reveals (Figr. 1140 to 1141). Some closing shutters lie against the surface of the wall or of a rebate, (Fig. 1110 a), they fit into a small rebate (Fig. 1140). On the contrary glazed windows have from the very earliest time onward splayed jambs, by which with the small width of window in relatively thick walls the light must be admitted. The splay is shown in its plainest form (Figs. 1143, 1143 a), or it occurs in combination with mouldings more or less rich (Figs. 1143, 1143 c), or it is entirely lost in mouldings (Fig. 1145),like the jambs frequently occurring in Middle Gothic (Figs. 1144, 1144 a) or in Late Gothic (Figs. 1145, 1145 a). As a typical example of a stepped window jamb may be taken Fig. 1142; Fig. 1142 a shows the same transferred to brickwork from the west-building of the cathedral at Riga (middle of 13 th century). Further examples of jambs are contained in Figs. 1146,1143 to114

The relations of the window to the covering side arch have already been described above (p. 350), and likewise it has been already stated, that the window jambs in some cases may coincide with the sides of the buttresses, or even be sunk in them.

Wall mullions.

For windows with middle mullions the regular development of the tracery (see below) requires carrying down the members of the mullion on the side jambs, so that here result half mullions, the so-called **wall** mullions.

The wall mullions are connected with the jambs, or where these are absent, with the buttresses, so that their separate piers remain in the height of the courses. More rarely they consist of tall blocks set on end, which then in the manner shown later for tracery are connected with the jamb. More frequently occur both conditions combined in the same window, as shown on p. 172 in regard to the rounds.

Window sill.

On the lowest block of these remains the start for the window sill (a in Fig. 1146), in whose height are generally taken the bases of the little columns b accompanying or forming the mullions. This construction is opposed to that commonly used, whereby the window sill is made of one piece for the entire width of the window and passes beneath the jambs, and is preferred since it avoids the breaking of the sill, that must occur if the sill extending under the jamb is chinked underneath the middle and a strong settlement of the jamb occurs. A distance of the end joint from the jamb members and thus the hook-shaped form of the stone are necessary to prevent water from flowing down the jamb and directly entering the joint. According to the thickness of the wall, the window sill consists of two or more ashlars laid on each other, or of but one for less thickness. The existence of bed joints then leads to making the angle of inclination of the sill greater that 45°, so that the edge c of the cut stone may not be too acute. Sometimes according to Fig. 1147 the upper stone of the sill is made of a stone with the width of the mullion, yet so that a lower wash does not continue the upper one, but a little vertical fillet a is left, below which continues the wash, while it may pe continued in a horizontal surface inside. It should be noted, that a steeper inclination of the wash is ever favorable, if possible for more

than 45°, and by the contrast to the other vertical and horizontal surfaces produces an animated effect, the arrangement of the bases of the little columns connected with the mullions is made easier, and opposed to flatter inclinations afford the advantage of being visible to greater height. The bases of the columns may either all lie at the same height, or as in Fig. 1146, these may be determined by the bed joints at different heights, They seldom lie above the window sill.

Window mullions.

The isolated dividing mullions are made of tall blocks standing on end, and on the older works maintain their vertical position by their weight alone without continuous iron bars. On the contrary on many later works the mullions are made so very slender, that this aid is required. No explanation is needed, how very much preferable is the older way and how injurious may become that iron bar. But since an increase in proportion to the increasing height has its limits, among others the appearance must lead to a greater width of panel than is favorable to the plan of the glazing, it must be advisable to restrict the height of the mullions, either by a reduction of the height of the entire window, or by a lowering of the tracery, so it already commences below the base line of the window arch. By the latter procedure (as we shall soon see more clearly), the weight of the tracery and thus the loading of the mullions will therefore sometimes increase the stability. On many works of the 14 th and 15 th centuries is found a stiffening of the mullions by cusped pointed arches, that are also sometimes connected with richer arrangements of tracery, trefoils, quatrefoils or squares with cusps, thus creating a cross connection of the mullions at half their height, commonly the arches being omitted, the connections merely consisting of squares arranged side by side or even of horizontal mullions.

On the lower block of the mullions remain the starts for the sill in the same manner as for the wall mullions (Fig. 1146).

Insertion of the tracery.

The whole of the tracery is then inserted in the window arch in the same way as the wood paneling in the frame, either in an angle (Fig. 1148) or a hollow (Fig. 1148 a). Besides there is frequently a recess (Fig. 1148 c) or a groove and tongue, (Fig. 1148 b), that is only short by the nature of the stone

and the purpose, 3 to 5 cm long but broad. By Viollet-le-Duc is also mentioned another construction by which the tracery stops abruptly under the window arch and by certain clamps projecting from the latter the supporters of the capitals are insured against all movement sidewise.

The tracery in some cases forms a centering arch for the window arch and must then be erected before turning the latter.

Dimensions and loading of the mullions.

Size and form of cross section.

To establish definite proportions of dimensions between the mullions and the thickness of the wall, as the later middle ages seem to have loved (p. 352), for example to make the depth of the mullion 1/3 or 4/10 of the thickness of the wall, must be termed a tradition of the early time and a procedure taking little account of static requirements. There was nothing in the way of increasing in dimensions the mullions of small windows to place them in harmony with the jamb mouldings or with larger neighboring windows, but in general there is nothing decisive but the size and especially the height of the window, so that small windows in thick walls can be satisfied by relatively slender mullions, while conversely for high windows in thin walls almost the entire thickness of wall must be used to be stable.

The ground plan of the mullion is made thin with reference to the admission of light and is splayed outside and inside in harmony with the jamb (Fig. 1149). On the contrary the depth of the mullion is considerable, since in this direction it must resist the wind pressure. Most ground plans of mullions can be referred to about the simplified ground plan of Fig. 1150, after equalizing projections and recessions. Such a ground plan of the average thickness b, outer and inner widths of $\frac{b}{2}$ and a depth of 2 b, has an area of $1.5\,b^2$, and in the greater direction a moment of inertia of $\frac{5\,b^4}{12}$, or in the smaller direction one of $\frac{5\,b^4}{64}$. The inserted figure of the kern has a length of $\frac{10}{33}$

The mullion must be sufficiently strong, that it is not crushed under its load, that it does not bend sidewise, and finally that it is not bent by the wind.

Maximum load for resistance to crushing.

With not too slender mullions, the loading that can be assigned to them depends only on the resistance of the material to

crushing. On account of the readily occurring change to an excentric load, it is advisabletto keep the stress within moderate limits, and with an abundantly 10-fold safety, to allow only 5 kil per sq. cm for brickwork in lime mortar, 10 kil for good bricks in cement mortar or ordinary cut stone, and at most 20 kil for hard cut stone set with special care. Accordingly a cross section of the form of Fig. 1150, 15 cm thick and 30 cm deep has 338 sq. cm area and if executed in ordinary brickwork could receive 5 × 338 = 1690 kil, or in hard cut stone 20 × 338 = 6720 kil. In Table A on p. 496 under P are given the permissible total loads (load + weight) for a number of cross sections of mullions.

Loading and height of mullion on account of buckling.

If the mullions exceed a certain height, the danger of buckling will be greater than that of crushing, in consequence of which this load is then to be kept within correspondingly smaller limits. Calculate by the given formula the permissible load N for the height of the mullion, (and conversely) by the general formula for buckling:-

$$N = n\frac{\pi^2 E J}{s l^2}.$$

Here N = load resting on it together with the weight of the upper half of the mullion in kil; n is a coefficient depending on the mode of fixing the ends, and here by correct construction lies between 1 and 4, but for safety is only made = 1; $\pi^2 = 3.14^2 = 10$ in round numbers; E = modulus of elasticity, that according to the certainly still defective investigations for bricks is given at 150,000, for soft cut stone at 250,000, for hard cut stone at 400,000:- J is the moment of inertia in the direction of bending; s is a coefficient of safety that may be taken at 10, and finally l = length in cm.

If no storm bars exist, the mullion would bend sidewise, and thus the least moment of inertia ($\frac{5}{64} l^4$ in our cross section) is to be considered. The Table gives under J_{min} these moments of inertia for different cross sections, and further in three columns under l_1 is the permissible height of the mullion for a full load P, with half that load, and for the effect only of its own weight. A mullion 15 cm thick and 30 cm deep could be made for a full load 4.8 to 6.0 m long, for a half load 6.8 to 8.4 m, and for its own load alone 12 to 16 m, to have the desrable 10-fold security against budging sidewise.

If it be then assumed that the storm bars form a sufficient stay between the mullions, then bulging can only occur in the direction of the depth. The maximum moment of inertia is then found in the Table under J max, while the allowable lengths of the mullion are found in the 3 columns under l_2 The permissible length under full load is about 40 times the depth of t the mullion. If with model execution and perfect building materials one would be satisfied by smaller safety (5 or 2.5 instead of 10-fold), then the tabular values could be increased 50 to 100 per cent, so that with sufficient staying sidewise the mullion could be made 60 or 80 times as high as deep.

The possibility of such a slender mullion depends on the conditions of the elasticity and resistance of the stone, and also round or square piers of stone can be relatively much more slender than those of wood or iron. While for a round or square wooden post with a length equal to 10 to 13 times its diameter buckling occurs more easily than crushing, this is found for a stone pier to occur first at 25 to 40 times its diameter, a fact again correctly recognized by the ancients, when it must have been utilized, as among others is shown in the p piers in the castle at Marienberg, the Brief chapel at Lübeck, a side chapel of the cathedral of Riga, and the slender little columns before the rose window of Strasburg minster. For heavily loaded piers moreover one would do well not to make the s slenderness more than 1 to 20 or 1 to 25.

Allowable height against wind pressure.

If thereby greater latitude is left to the length of the mullion in regard to the danger of bulging, the closer will the limits be chosen if the window is exposed to a strong wind pressure, as shown in the last three columns of the Table, which are calculated by the formula given below. A brick mullion 15 cm thick and 30 cm deep accordingly with distances apart of 75 to 100 cm can only be 3.5 or 3.1 m long, with execution in cement mortar, or 5.3 to 4.3 m in cut stone, or for hard cut stone 7.1 to 6.1 m. These are no great lengths and still for windows placed high only a moderate wind pressure of 120 kil per sq. m is taken, while a strong edge compression up to 10 kil per sq. cm is taken for brick in lime mortar, 20 kil in cement mortar or for cut stone, and 40 kil are allowed for hard cut stone. To go much above the tabular values is not advisable accordingly,

the more that the stress increases in the square of the proportion to the length of the mullion, and the danger of irregular construction increases. If the values were exceeded 2 to 3 fold, then even with faultless conditions a destriction would be expected, and too slender mullions could only be made durable by sufficiently thick and continuous storm bars (p. 492), that firly fasten the mullions to the jambs. Aside from the danger of rusting, the dependence on continuous iron bars has the great defect, that mullions are braced and the vibrations loosen the joints before the flexible bars become effective.

Least load for preventing bending by the wind.

The wind exerts on a mullion an effect similar to the load on a straight arch, in consequence of which the upper and lower ends of the mullions receive end pressures comparable to the thrust of the arch, which the masonry resting on the mullion at top tends to compress. Therefore a sufficiently great weight of masonry can oppose the upper end of the mullion. Thus besides the upper limit of load on the mullion (P in the Table), there is also a lower limit, if the wind does not break the mullion. This fact is of sufficient importance to demand a closer consideration.

So that the mullion may not be broken by the wind, there must be formed in it a line of support with the rise x and the end forces D (Fig. 1151). Establishing the moment equation for one half the mullion there is obtained for D and x the relation:-

$$D\,x = \frac{w\,l^2}{8}.$$

In this l = height of the mullion in cm, w = wind pressure acting on 1 cm height of mullion and glass surface. At the upper end of the mullion must the end force D or more accurately its vertical component be just as great as the upper load on the mullion, end if this is fixed, then the rise x of the line of support is to be obtained by the equation above. The smaller is D, the greater is x, but the latter must not exceed a definite magnitude, if the mullion is to remain permanent. If x equals the depth t of the mullion, rupture will certainly occur, for the tensile resistance of the mortar cannot be especially relied on here. Usually x is not taken at more than about half the depth of the mullion, or it would be safer if not over the length of the kern ($\frac{10\ t}{36}$). When such an $x = \frac{t}{2}$ or $= \frac{10\ t}{36}$ is inserted in the equation, then is found the least permissible

value of the load D on the mullion. (See Table that is established on the assumption that $x = \frac{t}{2}$).

Example. Required the least load on the ordinary cut stone mullion 4 m high, 20 cm thick and 40 cm deep, so that it may afford sufficient security against wind pressure of 120 kil per sq. m, when the distance of mullions on centres is 90 cm. In the formula are inserted x = 20 cm, l = 400 cm, $w = \frac{120 \times .90}{100}$ = 1.08.

$20\ D = \frac{1.08 \times 400^2}{8}$ 5 hence D = 1080 kil = least load. (For x = 40 cm, D = 540 kil, and rupture would already occur). If greater safety is desired, then x is made = the length of the kern = 11 cm, which gives as the least load 1960 kil or 2000 kil in round numbers. The maximum permissible load P on this mullion according to the Table = 6000 kil, which includes its own weight of about 500 kil, and thus the maximum extra load = 5500 kil. Therefore one must design so that the mullion has a maximum load of 5500 kil or a minimum load of 1080 or better 2000 kil, thus 1/2 to 1 cu. m of stone.

Similarly may be calculated for every case a maximum and a minimum limit of loading, which further coincide more nearly, the more that the length of the mullion approaches the upper limit. For the lengths of the mullions given in the last 3 columns of the Table, the maximum and minimum permissible loads c coincide entirely with the load P, if the condition be established, that the pressure remains within the kern, and the edge pressure shall not exceed 10, 20 or 40 kil. For relatively long mullions the load must be determined with especial care, if the material is not to be stressed unduly.

In Table B for six different cross sections of mullions are given the least loads for safety with a wind pressure of 120 kil per sq. m, indeed for average distances between mullions of 0.75, 1.00 and 1.50 m, with a height of mullions from 2 to 10 m. For comparison are given the maximum limits of the loads required by compression, that already are in Table A, but are again repeated in the last 3 columns. On this Table it may be stated, that the minimum loads given under D suffice for well executed windows not too much exposed to storms, but with inferior execution and exposed location is required an increase of 9/4 or double, while on the other hand for especially protected windows the loads on the mullions may be als reduced.

For Tables A and B see the original work, p. 466, 467.

Note on Table A. Lengths over 10 m are given in m, over 25 m are not included.

In flexure by wind is assumed no resistance, but the seldom occurring edge pressure is taken as double the average compression, thus being 10, 20 or 40 kil per sq. cm, according to the material.

Note of Table B. The Table applies for a wind pressure of 120 kil per sq. m with the assumption, that in each cross section of the mullion the compression remains within the middle half. (Rise x of the pressure curve = $\frac{1}{2}$t, see Fig. 1151). It is required that the compression remains within the kern (x=, $\frac{10}{36}$t(, so that the values of D are to be multiplied by $\frac{9}{5}$. A continued reduction of the tabular values of D with even the best execution would lead to destruction, even before the limiting value of $\frac{1}{2}$ D is reached.

Application of the preceding results.

Limitation of the heights of mullions by tracery.

A. Length and dimensions of mullions. It has just been shown what limits of the height of a mullion of definite cross section are given by the danger of buckling, and even more by the window stress (p 495 and Table A). To observe these limits, it is simplest not to make the window excessively high, and to give the mullions themselves a sufficiently large cross section. But now in some cases an increase in the height of the window may seem worth making without too great strengthening of the mullions. The nearest means for this was already provided by the earliest Gothic, and was afforded by window tracery extending far downward, that has a practical value not only in an architectural but in more than one respect also (p. 500). A comparison of the late Gothic window (Fig. 1152) with the Early Gothic tracery window (Fig. 1153), shows how markedly different are the lengths of the mullions in windows otherwise made of equal dimensions.

A second means of limiting the free length of mullions is afforded by a tracery arcade in the lower part of the window. (Fig. 1154).

Transverse stiffening of high mullions.

Also where these do not suffice, there remains as a third means an intermediate stiffening of one or even several places

above each other, as a b in Fig. 1155. These may consist of a horizontal mullion bar, of a series of arches with or without gables (Fig. 1155 b) or finally by a series of panels of tracery (Fig. 1155 c); in some cases a passage may extend across for watching the window at such places, that can be supported by an arch from the jambs or by special supports underneath, and so can contribute more effectively to the stiffening of t the window.

All these transverse stiffenings whether made by the middle division a b, the lower arcade at c d or by the upper area of the tracery at the height e f, have to prevent not only the buckling of the mullions but also the bending by the wind. Therefore the stiffening seen in plan (Fig. 1156) must act like a horizontal arch. The wind pressure against the mullions and glass will contribute to the stiffening, and at the point p of the stiffening (Fig. 1155) acts the wind pressure on the hatched area, which is easily calculated by multiplying the area of this surface by the unit pressure (120 kil per sq m). Thus each intersection receives its definite wind pressure, as K_1, K_2, K_3, in the plan, Fig. 1156. These forces combine in a line of support with the rise x, which can be followed further by graphics or calculation. For the last method a small example may find a place.

Example. A window 3.6 m wide may have 3 mullions averaging 0.9 m on centres, which are of cut stone and exhibit the cross section in Fig. 1150, 20 cm thick, 40 cm deep, 600 sq. cm in area, 11 cm length of kern. At mid-height the window has a horizontal bar of the same cross section (a b in Fig. 1155), and above and below it the free length of the mullion a e and a c is 5 m. The wind pressure on each intersection (the hatched area) accordingly amounts to 5.0 × 0.9 = 4.5 sq. m, and 4.5 × 120 = 540 kil = $K_1 = K_2 = K_3$ (Fig. 1156). Establishing the requirement that the line of support must remain within the kern, then also x = 11 cm, the moment equation for the half A B of the brace on which the pressure K_1 and half the pressure K_2, with the pivot M:- $H\,x = K_1 \times 0.90 + \frac{K_2}{2} \times 1.80$.

Inserting the valueu of x = 0.11, $K_1 = K_2 = 540$, the thrust in the brace is; H = 8333 kil.

This would produce in the cross section of 600 sq. cm an average compression of $\frac{8333}{600} = 14.7$ kil, or with the assumed rise

= length of the kern a maximum edge comperssion being double, thus 29.4 kil edge compression per sq. cm. These pressures are still permissible with very good execution for quite strong cut stone.

For stone of less strength or a still greater breadth of window, the simple horizontal mullion bar would no longer suffice, and then would have to be chosen a stiffer arrangement, like two bars above each other and connected by tracery, which would then divide the work. A similar stiffening must be possible in the direction e f of the arcade c d at the lower end (Fig.1155), the pressure area of the wind is here somewhat less.

Since the cross bars have to act as horizontal arches, the end joints in them will be cut obliquely to correspond.

B. Loading of the mullions. Farther above (p. 494 and Tables A and B), there is shown how great a load the mullion can bear without too great stress, and on the other hand what minimum load it must have in order not to be broken by the wind. It is then to place this load skilfully on the mullion; it may either rest comfortably on the mullion or it may become effective when the wind tends to bend the mullion.

Loading by the tracery.

1. The preferable solution is always obtained when the tracery alone is sufficiently heavy to serve as a sufficient loading, which is the case in most Early Gothic tracery windows. The best construction occurs when the mullions and tracery are first inserted after the setting of the other masonry., so that an open joint remains between the tracery and window arch; while the falling out of the tracery is prevented by tongued connection, etc. (Figs. 1143 to 1143 c).

Occasional loading by the window arch.

2. Another case occurs when the tracery of itself is not sufficiently heavy for the mullions to be resistant to the wind, but it lies beneath the window arch, so that here usually no considerable transfer of force occurs, that on the contrary in wind the tracery can be strongly loaded. Naturally the weight of the window arch with the masonry lying on it must be at least so great, that it can be raised (Table B), but on the o other hand this upper mass will be increased without limit, s since it usually does not press on the mullions.

The correct relation of the different parts strongly depends

on the mode of execution. If the mullions have settled too little, the window arch will lie on it.(And the tracery and crush them if the load on the window arch is very great. See p. 501). On the contrary if the mullions have settled too much, so that between the tracery and the window arch is an open joint, and if this be only 1/2 or 1 mm thick, there occur in wind on account of the rigidity of the stone injurious movements and edge pressures, that in some cases may become damaging (p. 502). T Therefore in the construction according as it settles more or less later or at the same time, in the last case the tracery can even be utilized as a centering for the window arch, when it can be recommended that between them be inserted lead keys at small distances, which can prevent too great a transfer of pressure from above.

Just as in the manner described, the tracery under the window arch supports it, in windows of compound systems the smaller system stresses the larger one in the wind, which in a similar construction of both is also done with greater security. Since the strong cross section of the larger mullions are also carried up in the tracery, so as its weight is advantageously increased, so that such a compound window is to be termed a favorable construction, whose general effect is mostly to be referred to Case 1.

Permanent loading by the window arch.

3. The third case consists in this, that the window arch with its load presses permanently on the tracery, thereby keeping this and the mullions under compression. This effect can be m more safely obtained, when the mullions and tracery are executed in a material settling less than the other masonry, and the window arch is turned over the compound tracery as a centering; now if the masonry settles at the sides of the arch, the arch itself will rest on the tracery, even hanging on it, which may even result in visible cracks. According to the proportion of the settlement will the arch represent only the little hatched portion of the masonry d f e (Fig. 1157) or the greater portion m a b c n; it may also be possible that commonly but the small part rests on it, but in wind if its weight is not sufficient, the greater piece of the wall participates.

At whatever inclination the lines m d and e n rise depends on the bonding of the masonry. The total weight of the arch

with the overload m d a b e e n in the calculation of the possible vault or roof loading must at least be so great, that the masonry in wind is not raised by the mullions (see D in T Table B) and must at most be so great, that the load on the mullion remains below the allowable limit (see P in Tamles A and B), otherwise this kind of stress in the mullions is not in place. The tracery loses very much in importance by this mode of construction, so that it is strongly restricted or can even be entirely omitted, and the mullions are then directly beneath the window arch as in mann works of rate Gothic and Renaissance; thereby is produced the most tasteless expression of this mode of execution, which genelally is least satisfactory in construction and taste.

The best solution always remains one sufficiently heavy, with simple or compound tracery, that does not require the aid of the window arch at all, or only needs to stress it in the urgent cases. The magnitude of the load of the masonry built above the window is then made entirely independent of the window itsel

Execution of the joints.

3. Execution of the joints and crushing. Joints are recently made in lime or cement mortar, where it is to be considered, that lime mortar settles more and remains plastic longer, while cement mortar quickly sets and thus its volume changes less. Which mortar is more suitable is to be decided only in each case, where the preceding considerations of the loading of the mullions afford the necessary indications. With high mullions of cut stone in cement mortar in order to make slight crushing not injurious together with the resulting excentric transfers of pressure, it is strongly recommended to fill one joint with a lead plate, upper or lower, or better three joints, nameln the upper, middle and lower, indeed best so that the joint remains open at the outer and inner edges for 1/2 to 1 cm.

Too long and too short mullions.

Although stone also does not lack a certain elasticity, it can change its length only within moderate limits. If a stone bar be compressed more than 1/10,000 of its length, the stress generally considered as allowable is already exceeded, and if the shortening is continued, most stones will be crushed before the shortening attains 1/1000. By compeession a mullion, when in consequence of too great length,is too strongly loaded, th-

therefore it can only avoid this overloading when the difference in length is very small. An elongation of too short a mullion can usually scarcely come in question, since with the slight resistance of stone and mortar to tension the joints will open very soon. Therefore it is briefly indicated to follow to a conclusion what danger may result to the mullions, if in consequence of crushing or of unequal settlement certain joints open.

Formation of open joints.

For windows with heavy and loosely set tracery (Case 1, p.500) an opening of the joints is not easily feared; if the mullions settle the tracery moves, so that between it and the mullions can no joint open, but a widening of the joint above the tongue before provided in this case in the groove beneath the window arch is injurious. Only when the tracery is firmly fixed between the jambs could also be formed an injurious open joint between tracery and mullions.

More to be feared is the opening of joints in windows, that assume a direct transfer of pressure from the window arch to the mullions ((Cases 2 and 3, p. 500), and indeed the opening between window arch and tracery or between tracery and mullions occurs, we shall briefly treat only the latter..

Tipping of the mullion at an open joint.

If no side forces act, the opening of the joint would be of no consequence, but when a strong wind occurs, even a very low mullion without upper load will tip on the lower edge B (Fig. 1158), since the pressure area of the wind is great and the weight of the mullion is very small. If the open joint Z is sufficiently large, the entire mullion may overturn, if any restraint by storm bars is absent, and indeed mullions with length l exceeding 10 times the depth t will overturn when Z = 1/200. More slender mullions with lengths of 15 t can fall if $Z = \frac{1}{450}$, and very slender ones occur with l = 20 t, even if $Z = \frac{1}{800}$. A mullion 6 m long and 40 cm deep (l = 15 t) might also overturn unhindered when the joint has at least $Z = \frac{6}{450}$, thus 1.3 cm or 1 1/3 cm.

If the joint be thinner, the mullion would not overturn without hindrance, for the edge E would rest against the upper surface as shown in Fig. 1158 a. If in the example given with the mullion 6 m long, the joint is only open 1/3 cm instead of 1 1/3 cm, the angle E would lie beneath the middle of the upper surface

But the mullion would not probably remain in this position, but would break in the next moment as in Fig. 1158 b. Then a line of support would be formed through the points F C B, which exerts a great lengthwise pressure (p. 495). Since the deges in contact could not transmit this pressure, the stone would crush at them, until a sufficiently large contact area is produced, (Fig. 1160 a), and then occurs no splitting off of the greater part (Fig. 1160 b), so that a mullion of very hard stone in the case would come to rest, and would remain protected from breaking. Whether the mullion returns to the original position after the stopping of the wind is doubtful, but in any case by repetition of these movements could easily be destroyed.

Breaking of the mullion at an open joint.

Far less dangerous is the open joint if the overturning of the mullion in its entire length is prevented, and the opposing thrusts of the ends are avoided by doweling (Fig. 1161 d), or by cutting the joints as in Figs. 1161 to 1161 c, or finally by grooving the storm bars in the upper and lower ends. If it is feared that the opening may indefinitely occur in the upper or lower joints, thus the displacement is to be prevented in the latter. If the settling of the mullion forms an open joint Z at top, so that the mullion can break as in Fig. 1159, for this is at least 4 times as great a thickness of the joint as for tipping as in Fig. 1158. The preceding mullion 6 m long must then have a play of 5 1/3 cm in order to free itself.But since great pressures are not to be considered, onln a moderate bending is to be expected, as shown in Fig. 1160. Then three joints open and aline of support B C G is formed, that again causes crushing of the angles furtunately (Fig. 1160 a), yet not without always coming to rest. When large pieces are broken off (Fig. 1160 b) there results a crash, and the stress at the points of contact ever moves toward the absolute limit of resistance, from which it results that open joints in the mullions of windows are not entirely inconceivable, unless by strong c continuous storm bars destriction is made impossible. Since the lack of the latter at other places has already been illustrated, it is advisable to devote the necessary attention to the construction of the mullions. Most reliable will always be windows with heavy tracery inserted in over the mullions in grooves, as to be emphasized later. If further the mullions, as in many

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Early Gothic examples, consist of a single strong stone, that is prevented from tipping by anchoring beneath the tracery, t then naturally is thereby met all danger most effectively. But also the other arrangements with careful execution will show themselves permanently allowable, unless great pressures occur to loosen the entire structure of the building.

2. Arches and window tracery in general.

Development of tracery.

The word Masswerk (tracery), i.e., measured work, is in contrast to foliage or to ornament formed by a free hand, and it accordingly denotes the transition from purely structural to ornamental foems. According to the place and the tendency of its employment the former or sometimes the latter element predominates in it.

Tracery consists of geometrical ground forms arranged beside or inserted within each other, that either retain their simplicity or are more detailed by a combination with other forms. Perhaps in no other form is expressed the ground law of Gothic art:- that all must serve the highest purpose and every part be subordinate to the whole, most clearly in the tracery, that even makes abstract mathematical figures serviceable by a detailing, that only demonstrates more plainly the essential peculiarities. It is like geometry brought to life.

But the tracery is no mere surface decoration like the Greek fret and the Moorish interlacings of lines, but by means of its members having depth it is a form in space, an independent wall, that may be either perforated or closed. Since Gothic art proceeds to form the entire architectural mass with a strongly c connected skeleton, or according to the modern expression, to substitute strength for mass, then in tracery the skeleton consists of the members enclosing the different figures. The elastic strength of the lines replaces the masses omitted in the perforated or sunken panels, and the constructive principle of the entire architectural work is thus reflected here at a small scale.

But in a neglect of this structural importance lay a danger of misuse. The corporeal tracery became a surface decoration, that indeed is very rich and charming, but according to an estimate of its value, it can only be placed in the same line with that Moorish surface work. At the end of the middle ages

columns was not relieved thereby. This could first occur when the separate arches were replaced by a great and common blind arch extending over all openings, this passing through the entire thickness of the wall as a relieving arch. Then the wall beneath this arch could again be reduced in thickness and even placed on a single row of columns, omihhing the cap stones (Fig 1163, cloister at Riga, beginning of 13 th century).

Thus already for a continuous wall, whether it supported vaults or not, the great thickness led to combining the openings, and the introduction of cross vaults with buttresses dividing the wall into separate panels, indicated this so much the more.

Best can be followed the influence of vaulting in the treatment of windows in the middle aisle of the basilica. The basilica with beam ceiling shows a continued series of separate windows, whose spacing often had no relation to the divisions of the lower arcade. By the use of cross vaults the windows must be regwlarly placed in the side wall. A single windou in each bay would generally afford too little light, so that groups of two or three others must be placed beside each other (Fig. 1165), but the Romanesque churches then betained heavy and deep jambs for small widths.

Relieving arch above several openings.

As an expedient was here again presented the relieving arch combining the windows, under which the thickness of the wall could be reduced, as this could serve as a separate arch, or it could take the place of the side arch passing through the entire thickness of the wall, and this was so much more possible in the beginning Gothic, since the supporting mass was t transformed to the pier (Fig. 1165 a) as the wall under the relieving arch no longer had to support anything, the piece of wall remaining between two windows could also be reduced in width, and the windows moved near each other (Fig. 1165 a). When in this manner two ordinary splayed jambs (Fig. 1166) were brought together, there remained between them a thin mullion with the plan of Fig. 1166 a, or if two windows flanked by columns came close together (Fig. 1167), there finally disappeared entirely the flat piece of wall (Fig. 1167), columns I and II were combined in a single column, and the remaining bit of the wall bemame the mullion indicated in Fig. 1167 a. Thus was formed in an entirely natural way the typical plan of a mullion

in Figs. 1166 a and 1167 a. In the plan of Fig. 1167 a men were led to insert the necessary intermediates to receive the rebate, when glazing was to be added in arcades with coupled columns (Fig. 1162 a). With the closely adjacent window openings were directly enclosed by the side arch (Fig. 1165) or by a separate smaller relieving arch when they did not occupy the entire length of the bay, has already been stated.

Perforating the tympanum of the arch.

If now two or more openings occur beneath a common arch, there remains a tympanum wall above them (Fig. 1163), aod to open this was naturally the next step indicated, and for this purpose could be employed one or more circles or some other geometrical figure (trefoil, quatrefoil). Fig. 1164 shows a perforated tympanum from an entirely Romanesque cloister at Königslutter, and Fig. 1168 one from the Early Gothic cloister at Fischbeck (both from Hase's Niedersachsen). At the window from the collegiate church at Wetter (Fig. 1169) three trefoils tolerably close together are employed. Preferably the tympanums were made of rubble or brick, the material determining the character of the openings. Even this first stage of the development of tracery does not lack its special charm. If the openings were not glazed, they could be most simply cut with rectangular jambs (Fig. 1170). The glazing may lie flush with the inner surface in the little rebate m, but chiefly is in the middle of the jamb, that shous the profile in Fig. 1170 a to c, elsewhere u usual on the mullions.

Tracery bars.

The openings soon increased in number and size and adjoined each other, so that they left little of the surface of the tympanum beyond them, and thus the jambs were so close together, that also the profiles shown in Figs. 1166 a and 1167 a originated here. These profiles then continued as curved bars around every opening so that they passed into each other at the points of contact (Fig. 1171), and also with the section m n of the same cross section in Fig. 1171 a exhibits a favorite and freer cross section n n of the bar. But thereby was completed the p proper devilopment of the tracery, where a single enrichment was yet added for great windows the arrangement of the main tracery in this inserted subordinate tracery, whereby in the tracery and the mullions equally originated the combinations

of the larger and smaller systems.(Figs. 1262, 1268).

Before we pass more fully to the window tracery, it is necessary to treat the different forms of the tseatment of certain ever recurring forms of tracery, such as polyfoils, cusps, fish-bladder, etc., in a connected form by themselves.

Romanesque forms.

Besides the simple round arch, Romanesque art very frequently employed both in arched friezes as well as openings for light and doors, the sportive trefoil arch (Fig. 1172) composed of several circular arcs, that besides a round also soon showed a pointed top (Fig. 1173). Likewise occurred in place of circular openings (Fig. 1174) cross-shaped or those of purely ornamental form (Fig. 1175 from Naumburg, according to Redtenbacher), but more commonly appeared trefoil, quatrefoil and p polyfoil openings (Figs. 1176, 1176 a, 1176 b), that are named according to the number of circular arcs, trefoil,(Fig. 1176 b), quatrefoil (Fig. 1176), cinquefoil (Fig. 1176 a), or generally polyfoil. The jambs were cut square or surrounded by mouldings, when the projecting angles or the cusps frequently had rich ornamental terminations. The openings were frequently cut through single slabs of stone, or where this was impossible, men sought to make the ashlars as large as possible, and the joints were mostly cut square across the mouldings. In Figs. 1172 to 1176 are given various modes of jointing.

Early Gothic forms. Cusps with full bar moulding.

All these forms were first transferred to Gothic almost unchanged. Then when men began to separate the perforated slabs of the tympanums into tracery bars, the outlines of these figures were constantly suffounded by the bar moulding. The angles or cusps were also formed by the complete bar moulding (Fig.1177). Forms of tracery of this kind that combine trefoil arches and polyfoils in the most varied ways are particularly common in the second quarter of the 13 th century in use. Figs. 1235 to 1239 and 1241 give examples of them. About the middle of the 13 th century appeared in many places almost contemporaneously the proper cusp, that does not form a separate bar, but grows sidewise out of one as shown by Figs. 1178, 1179, 1181, etc.. The entirely free trefoil arch (Fig. 1177) there returns to the pointed arch in which the cusps are added in the form of trefoils (Figs. 1178, 1182). To this transition may have con-

contributed the fact, that the free bar in Fig. 1177 in appearance and reality could be more easily broken, and did not seem as well suited to transfer stresses lengthwise. On the contrary this purpose was attained better by greater lengths, when the bar was continued also in the dotted line, and even at the middle, which usually broke first in buckling, there was obtained doubled dimensions.

Both on the pointed arch as on the trefoil arch enclosed by it could be carried around the full mullion moulding, as shown in the left half of Fig. 1178. But the cusp of the trefoil arch then seems rather dry and heavy, but will already become more graceful if the width of the moulding is somewhat reduced, so that the front surface n is only 1/2 or 2/3 the breadth m of the pointed arch, as in the right half of Fig. 1178. In the space or spandrel between the pointed and trefoil arches, the sides form a triangular sinking a b c or in some cases a free opening d e f remains, and the corresponding cross section of the cusp are shown in Figs. 1178 b and 1178 c. The opening in the spandrel is sometimes avoided by the insertion of a flat panel, or it is enclosed by flatter chamfers intersecting in a line (Fig. 1178 d).

Cusps of less thickness.

But the same depth of moulding on pointed and trefoil arches belongs rather to unusual forms, as just explained by Fig.1178; as a rule the inserted trefoil arch shows a moulding of less depth (Fig. 1179). The origin of this solution may eventually be referred to those Romanesque portals that instead of the solid tympanum have a trefoil arch inside the soffit of the arch. In the nave of the Strasburg minster is found the Romanesque round trefoil arch inserted in a pointed arch (Fig. 1180a) at other places is found already at the same time a pointed t trefoil arch in the pointed arch, but thereby is created no p principle; the cust is shown in Fig. 1179, and as it came into use about the middle of the 13 th century.

Allied to the solution in Fig. 1179 is the form of cusp in Fig. 1181, and in both the profile of the cusp already exists in the profile of the mullion, and Fig. 1181 exhibits the peculiarity that the surface a b extends directly into the spandrel. In the forms of Figs. 1182 and 1182 a the moulding of t the cusp is no longer carried down on the mullion, but on the

contrary in Fig. 1.83 the cusp projects freely from the side of the mullion.

It is the same Late Gothic mode of treatment, that shows itself in the springing of the rib from the pier (p. 99), and t that frequently leads to the intersection of different mouldings. likewise in tracery occur such penetrations, and thus in the tracery on the buttresses of the castle church at Altenburg, the cusp arches composed of fillets and cove project from the mullion consisting of a simple round.

Ending of the cusps.

If the cusps project but little, they terminate in an obtuse angle (Figs. 1181, 1182). Long cusps would have an acute angle, which is ugly and fragile, and therefore this is replaced by a wider end (Figs. 1183 a, 1184), when the radius of the arch is so shortened that the arcs do not intersect but leave a space between them.

This broad cusp that already occurs in the earliest tracery, especially on polyfoils and wheel windows, can be cut off square in the simplest cases, about on a line joining the two centres (1184 a, b, 1185). If it is extended farther, the arcs d diverge again at their ends (Figs. 1184 c, 1186, 1187), and c can again be cut off square, be made acute by two oblique surfaces (Figs. 1186, 1187). The moulding of the edge may stop dead at the end (Figs. 1184 ., 1186), or may be returned around it (Figs. 1184 b, c, 1185, 1187). Long projecting cusps extendind from broad chamfers or coves may occur, where at the end is increased not only the width, but also the thickness. (Figs. 1186 to 1188).

The cusp may have a richer termination by a head (Figs. 1188, 188 a) as in the church at Haina, by a heraldic lily (Fig. 1199), numberless examples of which are found in the earliest and latest times. Forms of the latter kind are especially suitable for ornamental arches of a polyfoil or trefoil.

Sometimes the cusps extend so far that two opposite ones are produced (Fig. .191). These are exaggerations in which the late time is not poor.

Cusps of the second order.

To the cusps preferred in the later time also belong the compound cusps, formed by inserting small cusps again in the main cusps (Fig. 1192), which mostly grow out of the main bars, like

the ordinary simple cusps. To be distinguished from these cusps inserted in each other are the frequently curved Early Gothic forms of tracery, in which the large and small cusps are formed by the complete bar moulding in unbroken course (Figs. 1238, 1241

Detailing the trefoil arch and cusps.

Trefoil arch.

The Romanesque trefoil arch in its most severe form shows at the sides two quadrants with a semicircle in the middle (Fig. 1193), and the latter may be stilted (Fig. 1193, right). Moreover there also frequently occur arches with much more acute angles projecting internally (Fig. 1194), the radii of the three arcs are mostly equal, since greater differences in their lengths do not please the eye, and in rich mouldings introduce difficulties at the intersections (more on those below on Fig. 1202). Especially great becomes the difference of the radii, if the two side arcs form parts of a semicircle according to Fig. 1195, as the form produced thereby with a round middle arc is not expressive. On the contrary with a pointed middle arc it is quite possible to draw the two side arcs as parts of a semicircle, and then use the same radius for the upper pointed arc. Figs. 1196, 1193 and 1198 give three different arches of this kind, where the parts of the arches have the s same radius. Fig. 1196 has the effect of a somewhat low separate trefoil arch, the upper centres being on the semicircle; in Fig. 1197 the centres are raised to the height of the crown of the semicircle, and in Fig. 1193 they are raised to far that right angles are formed at the points m and n. The last will always be attained when the distance of the centres d and e frog c equals the chord a f. The form in Fig. 1198 must represent the extreme limit for the slenderness of the middle arch, it is satisfactory in a certain measure, if the side arcs are stilted by a g to have equal rise.

It is indeed permissible but not at all required, to strike the lower ones from the same point c, or any two chosen points c and may be employed (Fig. 1198), likewise it is not necessary to make the distances between the upper centres d and e equal to the radius, as occurs in the selected example, they can be placed nearer or farther apart, even the equality of the radii is onln advisable, but is not to be termed necessary. Moreover the simple trefoil shape not enclosed by an arch allows the

greatest freedom, and it is not forbidden to draw it in free curves without the use of compasses.

Cusps in pointed arches.

Far more restricted are naturally the trefoil arches that by the insertion of the cusps are formed in an enclosing pointed arch. So far it does not have to dominate the latter, but it also affords it the freest play; the sole rules that it is recommended to carry out are contained in the two next requiremen

1. That the cusp arches join the principal arch without breaks at the transition points (a, s, w, v, w) but tangentially.

2. That the radii for the two halves of the cusp are equal.

In Figs. 1199, 1200, 1201 are represented some examples of the construction of cusps, which all have in common that they satisfy the indicated requirements.

The first condition is always fulfilled if the centre of the cust arcs,(2 or 3) lies on the straight line drawn from the c centre of the principal arch (1) to the point of transition. Thus in Fig. 1199 the point 3 must be on the line 1 s, and likewise in Fig. 1201 the point 2 lies on the line 1 u, etc. From the second condition follows, that the centres 2 and 3 of the cusp are on an arc struck from the principal centre 1.

If one does not obey the latter, the concentric profiles intersect in a curved line after the manner of Fig. 1202, whereby the cusp appears curved. If also the latest Gothic did not recoil from such peculiarities, but often sought them, the better period justly avoided them.

Fig. 1199 shows a principal arch with small rise, the radius 1 s being only 2/3 of the width a b. The cusp arcs that first join the principal arch at the ends a and s, are struck with a half radius, thus $s\ 3 = a\ 2 = \frac{a\ 1}{2} = \frac{a\ b}{3}$. The cusp a m s formed thereby is pretty stumpy. By reducing the radii, thus transferring the centres to 2′ and 3′ longer cusps are produced.

Fig. 1200 shows an arch whose radius equals the width (inclosed by an equilateral triangle). The very stumpy cusp a m s is drawn with a radius = half the width, and the arc a m is thus a part of the semicircle about the centre 2. The centre 3 correspondingly on the middle of the line 1 s. Now if the radius of the cusp is made only 1/3 of the width, then $2'a = \frac{1\ a}{3}$, this would extend to the middle o and there join the opposite cusp. Within these limits 2 and 3′ will thus have to be located the

centres of the cusp. About in the middle between both is found a point 2″ or 3″, that produces a cusp right-angled at the fr-ont point m′. (Accurately calculated the radius a 2″=0.41 x ...

In Fig. 1201 the cusps do not extend the entire length of the principal arch, but on the left half they leave the principal arch at the points u and v, so that the same distances a u and v s may remain free above and below. On the right the cusp indeed extends down to the end point b, but it leaves the part s w free above. Raising the principal arch the distance b g the cusp again lies more in the middle of the arch. Forms like that shown in Fig. 1201 chiefly belong to Late Gothic.

The lines given in Figs. 1193 to 1201 give the clear area of the openings, the members are concentric around them and intersect in the way given above. Drawing them presents no further difficulty, so that it can be passed over here. Also for the case that in drawing one does not start from the clear opening, but from the middle line of the bar (Fig. 1234 a), most of the given forms of cusps are usable.

All these constructions, both the entire scheme of the tracery like the cusps, can be frequently modified and best so, if made after a previous freehand sketch, only serving to fix the character of the latter, which is least successful, if one scrupulously adheres to a geometrical development. Certainly this affords certain starting points, but thereby some part is encroached on, which is especially true of the interspaces, since they can unconsciously be departed from, and the compasses be set a little away from the geometrical point, even if not otherwise slightly reducing the width of the member of the bar a little at places, as then usually the cause of the magnificence, which is to be sought in a mediaeval work in tracery, before one belonging to restoration there or otherwise copied.

Drawing the polyfoil.

All that has just been said of the drawing of the cusp in p pointed arches may be applied to central figures of every kind.

Cusps within a circle.

When the Romanesque polyfoil is enclosed by a circle as those shown in Figs. 1176 to 1176 b, then is completed the transition to a tracery of central form, the incurved foils of the polyf-oil become inserted cusps. This course of development then cl-early appears, the curves of the cusps entirely occupy the in-

interior of the circle, and only in a few cases does the latter remain visible between the cusps struck with small radii, like the pointed arch between u a and v s in Fig. 1201. The cusps are either inserted in grooves in the enclosing circle, like the tracery in the window arch (Fig. 1148 b), or they are wrought in one stone with the accompanying moulding.

Laying out the cusps in the circle is based like that of the polyfoil on the simple division of the circle, as to insert 3 3 cusps the radius is laid off 6 times in the circumference and these points are connected, and the centres of the curves of the cusps lie on the diameters thus obtained. Their distance from the centre of the circle, C a in Fig. 1204 is laid off from C f half the width of the cusp b a on each side, parallels are drawn to C f and on C c is sought the centre for the cusp arches touching these lines and the great circle.

If the cusps are to be pointed as in Fig. 1204 a, the choice of the centre is made according to the degree of its acuteness, and can be limited to between the points a and b. In general it is better not to make the points too long, so that the centre is placed nearer a, as the excellent effect of the tracery in the north portal of the cathedral at Rouen shows.

Entirely in the same manner are obtained 4, 5, 6, etc. cusps. Fig. 1205 shows the insertion of 4 cusps or the formation of the quatrefoil, whereby according to the form that the cusps are to receive, the choice of the centre may be made between a and b.

Cusps in trefoil arch:

The insertion of the cusp in the trefoil may occur in very different ways as shown in Fig. 1206. First is the construction of the trefoil by three semicircles to be possible by 3 semicircles through the middle points of the sides of the triangle (thus a in Fig. 1206), whereby is obtained the form of the trefoil in Fig. 1207. The cusps then project little and correspond to the cusp curve in Fig. 1200. A form like Fig. 1207 a results if the centres of the arches in Fig. 1206 lie on the circular arc a d between a and d, thus about at e.

But both cusp curves can also be struck from one point and the cusp still remain pointed as in Fig. 1207 b, if the centre is placed at about f in Fig. 1206, and finally the form shown in Fig. 1207 c with a square cusp may result from a centre pla-

placed at h in Fig. 1206. Figs. 1207 to 1207 c show what different effects can be obtained by such slight modifications. The insertion of doubled cusps in these Figs. can occur in just such varied ways.

The insertion of cusps in the square is shown in various ways in Fig. 1208.

Cusps in the square and in the quatrefoil.

In the right half the middles of the sides of the sjuare are connected, and in the diagonal square thus formed is drawn a circle, the arc d c is bisected at f and from f etc. are struck the arcs of the cusps. Between the points d and f can the centres be moved to obtain a different shape of the cusp.

The left half of the Fig. shows the form of a square cusp. There is laid off from the line bisecting the square half the width of the intended cusp on both sides (Fig. 1204, parallels are drawn to C g that cut the sides of the square at i and k, then is drawn the line i k, bisected at l, and from l with a radius if the side of the square is struck the arcs of the cusp.

Fig. 1209 shows acute and blunt cusps in the quatrefoil, with centres indicated in the drawing. In some curves are inserted cusps of the second order. Further statements on the different possible positions of the centres may be omitted.

Various circular panels.

all previously shown forms of cusps and polyfoils can be inserted similarly in the circle. But a different mode of filling this is obtained either by the division with bars placed radially, which may then be beset by cusps, or by the insertion of circles as in Fig. 1214, or of other geometrical figures. Simpler forms of this kind are shown in the later succeeding figures of windows and rose windows.

The construction of Fig. 1210 results simply from the inscribed equilateral triangle, as indicated by the inserted aiding lines.

In Fig. 1211 are inserted 4 equilateral arches produced by 4 equilateral triangles

In Fig. 1212 3 square arches are placed in the circle. In order to draw them without long trials, there is employed a s subordinate Fig. 1212 a, in which is laid off a desired length a b on a horizontal line, and with thès length is struck from a and b the intersection c, a b is bisected at e, e c is drawn

and divided in three equal parts, marking the first point d, then on a b is constructed a square a b f g, from d is described a circular arc that passes through f and g, and c e is prolonged to the point h on the arc f g. Then the circumference of the circle in the main Fig. 1212 is divided in 6 parts, and to these divisions are drawn the radii i G, k C and l C, so t that only from i is to be drawn a line parallel to a h in the subordinate Fig. 1212 a, which cuts k C in m, to find an angle of the square arch m n o p. The other pointsaare found accordingly. The arcs of the square arch can be found by making from p and n with a radius i C an intersection s, and from this is struck the arc p n.

Fish bladder (vesica) and intersections of tracery.

Fish bladder.

Besides and according to the just explained filling of the circle by inserted geometrical figures, that with the fish bladder appeared in the 15 th century. Fig. 1213 exhibits the filling by 3 circles, that both touch each other and the great circle. If the dotted parts of the lines are omitted, there result 3 fish bladders. In the same manner are formed within the circle two fish bladders from two inserted circles, and f from 4, 5, 6 circles are as many fish bladders.

Fig. 1214 shows the insertion of 5 circles. The periphery is divided into 10 parts, from the dividing points are drawn radii a C, b C, and these are produced to cut the tangents at f in g and h. Then is drawn through h a line to the opposite bisecting point of C g, so that the centre i is given by the intersection of the latter with the line C f.

On the proportion of the fish bladder to the width of the m moulding will only be said here, that as a rule the assumed moulding of the tracery goes around in the circle and also in the fish bladder. According to its proportion to the diameter of the circle, also to the position occupied by the circle in the entire tracery, is therefore the arrangement of the fish blader, so far that its number must diminish when the diameter is less in proportion to the width of the moulding, and converse

Fig. 1215 then exhibits the insertion of cusps in 4 fish bladders in different ways, which may likewise occur for 2, 3 or more. First the line of the scheme is paralleled by the width of the moulding taken from the bar, and the cusps are then con-

constructed either on a line drawn from the centre c to C in the semicircle, as shown in the right upper half of Fig.1215, or in a greater circular segment, that is formed about according to the left upper half on the line c′c″ and the prolongation c′d of the line c′C. Then there lies one centre on the line c′e, the second on c′f and the third on the bisecting line cwg of the arc e f.

All previously shown fish bladders end with a round arch.On the contrary Figs. 1216 to 1218 exhibit the form of the pointed fish bladder.

In Fig. 1216 are first drawn the lines for dividing the circle into three equal parts, thus a c, b c and d c, then each of these lines like c d is divided into three equal parts, and from the point 1 of this division lying nearest the centre of the circle is struck arcs with the radius 1 d, which thus forms the equilateral arch e f g about the centre. The points 1, 1 and 1 are joined by straight lines, and these are produced beyond the circumference of the circle, thus from 1 to h, and t then are found on these lines the centres k, from which is struck the arc i l with the radius 1 a.

In Fig. 1217 are inserted 6 fish bladders. First are drawn the lines for hexapartite division, then a c is bisected at b, c b is drawn from c to d, etc., and then from b with the radius a b is struck the arc a d, likewise from the points d, etc.Now d b is laid off from d to f, and from f is struck the arc d b, and the process is repeated for the other points.

Fig. 1218 then shows the insertiog of 4 fish bladders. First are drawn the lines a b and c d for the division in 4 parts, then from b is laid off the distance b c to e, then f e from f to g, h and i, the sides of the internal square e g h i are drawn and produced to the other side, thus to k, l, ect, from h with radius h b is struck the arc b g, from g the arc c e, then from the intersection of the latter with the lines h k and g l, and thus from the points m and p the arcs n h, g o, etc., completing the construction.

Intersections.

Varied forms result from the intersections formed by the curves of the fish bladders. Such forms are shown by Figs. 1219 to 1225, whose construction results from the lines indicated, and which characterize the last period of Gothic art, the last

times of the 15 th and the beginning of the 16 th centuries.

In the filling of circles shown above, of the middle period by inserted geometrical figures these alwans assert a certain independence, if they already subordinate the principal form, and which is expressed by the inserted cusps. For the cusps really and essentially denote the limits of further divisibility. There indeed occur certain forms, that appear to contradict this rule, like that represented in Fig. 1222, where the circle with 4 cusps is divided in 4 parts by a cross again having cusps, without the importance of the rule being lessened thereby, for the cusps placed on the circle are just as well related to one of those forming quadrants, differing only from them by the greater radius of their arcs.

The adoption of the fish bladder first violated the principle of the independence of the separate figures. The fish bladder commences at its head as an independend form, but loses this character at its ending, which like a resolution corresponds to a disappearance. Now the cusps also had no longer a justifiable existence, and therefore were omitted, and all emphasis was placed on an exaggerated and labored bending together, and even intersections of the endings or rather of the bars forming them. In the increased intersection of the latter men further sought a substitute for the voids left by the omission of the cusps. But since the extension of these crossing bars was no longer restricted by any organism, and finally all threatened to overrun or to lead again into the old intentionally abandoned paths, there remained no means then to cut them off abruptly as done in Figs. 1219 and 1223 to 1225.

Gothic art represents in its works the supremacy of the cross over everything in existence. We do not say that men sought s such a symbolism everywhere, it grew up as it were. The basal form is that of the cross and includes in itself all possible conceivable forms, geometrical as well as freehand. The system of vaults is based on a twofold intersection in the direction of the sides as well as of the diagonals, and shelters all found beneath it. What is the pointed arch itself but a cross f formed by two parts of arches intersecting at the crown. It includes all forms in itself, the closed geometrical, subordinated to each other according to their location, magnitude and form, and the spaces as if serving for joining. To such a part

is given a location, each one must serve and over all together stands the cross. This subordination must first yield to the search for greater variety, instead of forming the whole for the parts and these from the different units, the latter are first brought into direct relation to the whole. While in Early Gothic works the polyfoil is the determining unit dominating the entirel form, leaves a certain justification of the interspaces as serving as a still suitable form, these are reduced in a measure that they formed closed geometrical figures from the polyfoils, which are undisturbed by the spaces and enclosed only so much area, as they could no longer use themselves. Thus the tracery of the middle period consists of closed geometrical figures like trefoils, quatrefoils, circles, etc., and the sometimes considerably crushed interspaces. It was also near to open the former as well as the latter, and thus at first to form only occasionally occurring fish bladders (as Fig. 1255 a shows), until finally this principle of joining e everywhere replaced the isolation of the geometrical figure, all difference between the stipulated and conditional figures disappeared, and finally all was simply formed by the intersection of its limiting lines.

3. Tracery with simple Mullions and Wheel Windows.

Mullion windows of Early Gothic.

Plan of mullions.

For reasons of stability and admission of light the cross s sections of mullions received great width and small thickness, as stated above (Figs. 1226 to 1228). The most natural and simple plan is accordingly a rectangle with angles chamfered to further favor the admission of light. Fig. 1226. The glaoing, p. 468, almost always is in the half depth of the mullion in a groove, see left half of Fig. 1226 or in a rebate, Fig. 1227. The usually narrow rebate is not less that 10 to 15 mm wide and extends on half the mullion by a chamfer, Fig. 1226 right. Adjoining the glass is a flat n b in Fig. 1226 or i k in Fig. 1 1227, which at least must be wide enough for the putty and the fastening tacks. From the point b may the profile diminish, so that only a width a c of the mullion remains outside and inside, that is 1/4, 1/3 or at most 1/2 of the entire thickness b d. Instead of the plane chamfer, Fig. 1226, there occurred already early a more or less flat cove, Fig. 1227 above, and the cove

can also extend in a flat e g (Fig. 1227, bottom left), or sometimes it is cut deeply into the mullion (Fig. 1227, bottom right)

Far richer and more graceful is the effect of the mullion, if a little column is formed at both edges, Fig. 1228. In the early period almost without exception this bore a capital beneath the beginning of the tracery, that was particularly unavoidable if the profile of the upper tracery differed more or less from that of the mullion (Fig. 1233). In the middle Gothic the capital and then also the lower base were omitted, and the column became a projecting moulding that branched into tracery above. In the first time the column is indeed found detached as a separate and projecting round set on end, but it is mostly wrought in the same stone. The column may lie before a flat of the mullion (Fig. 1228, top), or it may intersect the chamfer or cove (Fig. 1228, bottom).

The effect of the entire mullions is increased, the more the little column dominates the thickness by its diameter. That t the projection of the capitals shouldnot come too close to the glass, the depth of the mullion is to be increased, so that it may be nearly fourfold its thickness. Even then the little column has a clear effect, if it be separated from the rest of the profile by a straight or coved neck (Fig. 1228 a).

Instead of the round without capital a prismatic member may also be before the mullion, Fig. 1229, that likewise continues unchanged in the bars of the tracery.

When the tracery has no projecting cusps, the simple moulding in Figs. 1226 or 1227 may follow without change all the curves of the tracery. These cross sections also correspond very well to the elevations of Early Gothic tracery in Figs. 1234 to 1239 and 1241, although these could also be formed with richer profiles. With the existence of separate cusps as in Figs. 1240, 1242, care is to be taken in the development of the profile as previously done in Figs. 1178 to 1183. The Early time desired the cross section of the cusp to be already expressed in the lower mullion, wherefore for this purpose the profiles in Figs. 1228 and 1229 are well suited, in which the section of the cusp is indicated by hatching. In the later time men did not hesitate to permit the cusp to grow out of the simple mullions in Figs. 1226, 1227.

But where in the older works the forms of cusps occur with

a simple section in Fig. 1226, there the parts beset by cusps are changed to correspond, and thus on the windows of the sacristy of S. Elisabeth's church aat Marburg, the sectionof the mullion in Fig. 1226 in the trefoil with cusps has an addition indicated by the hatched part, that must indeed grow out of the mass of the dividing arch, since capitals do not exist. B But the last case proves, that the growth was nowise unknown in the Early time, but only preferably avoided.

Elevation of the window.

The general form of the elevation of the window in two divisions consists in this, that the middle mullion is connected by arches with the two jamb mullions, and the space remaining above these division arches and within the window arch is filled by a circle or another more or less complex form.

The simplest of these arrangements is the circular filling, yet this permits several substantial variations, that are outlined in Figs. 1230 to 1232.

In Fig. 1230 the main lines of the division arches join that of the great window arch and the radius of the circle filling the disk is determined by the heights of the arches.

In Fig. 1231 the circle is struck with a greater radius, and the main lines of the division arches are therefore lowered under the great arch.

In Fig. 1232 is found the same proportion of the main lines, and there is only the difference that the main lines of the separate arches do not join as in Fig. 1231, but merely pass by each other. This difference is clearly expressed in the cross section at ab and f g.

The last arrangement is peculiar to Early Gothic, and is found applied on different plans of mullions, as in the Liebfrauen church at Treves, the church of S. Elisabeth at Marburg and the church of the monastery of Haina. It makes possible, as well be seen later, many complex forms, while it brings the system of mullions to an independent termination, and allows a varied and more suitable form for the spaces between the great arch, division arches and the circle. But then it is especially justified, if according to the section represented in Fig. 1233 of the round extendind around the tracery proper has a smaller radius, than that accompanying the mullions and jamb arches, so that the two intersecting arch mouldings b c d and f g h res

on the capital of the mullion, hence the hatched portions form projections on the capital, and the cross section at f g in Fig. 1232 receives the form shown in Fig. 1233 a.

The most common scheme for the window of two divisions is formed by Fig. 1231, that forms the basis for many variations. First may the circle be beset inside by round or pointed arches, indeed by 3 to 8, while the division arches are simply pointed. Merely the simple contrast of the simple division arches to the rich ornamentation of the great circle exerts a certain charm. Fig. 1234. Instead of the simple pointed arch may be employed the trefoil shape for the division arches, as in the Early Gothic polyfoil windows in Figs. 1235, 1236. After the middle of the 13 th century very frequently occur division arches with inserted cusps, as the tripartite window from the cathedral at Erfurt shows in Fig. 1240, that likewise affords an example of a pointed polyfoil in the circle.

Laying out the tracery.

To lay out a tracery window, two different procedures may be employed. According to the first there are drawn the middle lines of all mullions and bars, and the width is then laid off at both sides; according to the second there are first drawn the clear openings of the main forms, the widths of the bars are laid off and then the clear openings of the subordinate forms. In some cases the two methods may be combined; it is always well first to determine the main proportions by a freehand sketch, and to adapt the geometric skeleton lines to this. Since where two bars pass into each other or intersect, there is formed a junction that shows the normal profile at the narrowest place, but in no case can be weaker than that. The least fault in this has an effect disturbing in the highest degree.

Window in two divisions with circle filling.

Some Early Gothic windows may now be mentioned with a brief statement of the procedure in laying out. A frequently occurring window, that on account of its natural development and its noble simplicity can almost be taken as the ground type of the Early Gothic tracery window in two divisions as shown in Fig. 1234. Its effect is intimately connected with the size of the upper circle of tracery, which on its own part is again in a certain dependence on the proportion of the height of the window, the breadth of its jambs, the dimensions of its moulding

and the requirements of glass painting, in general may it be assumed, that the tasteful effect increases with the size of the circle, as shown by . comparison of Figs. 1230, 121 and 123 In the last Fig. the circle extends down below the base line a b of the window arch, while on the windows of the choir at Rheims even the centre c is moved down to about the height of the base line a b of the arch. That even with this exaggeration the window at Rheims is still tasteful is to be attributed to the fact, that the circle member does not grow with the jamb member, but is inserted in that, whereby the size of the circle has suffered a slight restriction.

The middle lines of the bars are drawn in Fig. 1234, they join each other at the contact points m, t, etc., whereby the complete growth of the members is expressed. The centres a and b of the window arch in this case are placed on the middle of the mouldings, and they therefore form an equilateral triangle with the point s. At the centre of this equilateral triangle is then taken the centre c of the circle, Then ciis found by drawing the lines a c and b c at inclinations of 30°, or by bisecting the arches a s and b s at m and n, joining these points with b and a. The division arch at the left is also formed on an equilateral triangle d e f, whose apex d does not lie on the upper circle, but es clearly shown in the subordinate Fig. 1234 a remains somewhat distant from it. The point of contact t of the circle and division arch lies farther sidewise on the line e c. To find the points e and t without trials, about c is to be struck a circle with radius c m + e f, whose intersection with the middle line of the jamb mullion g gives the point e.

The detachment of the great circle from the apex of the division arches is seen more clearly in the window of three divisions in Fig. 1240, where even at i the rounds are distant from each other. On the window of two divisions the separation only becomes perceptible when the upper circle is quite small (a b in Fig. 1230). In the present Fig. 1234 it almost entirely disappears, and one can entirely avoid it if according to the scale of the right half of the Fig. the division arch is made more slender, so that the centre g is lower and nearer the exterior. To obtain g a vertical is erected at the middle of the opening that cuts the circle at i, and then is drawn the line c i on

whose extension must lie the point g.

When instead of the circle the window has a trefoil or quatrefoil, then the laying out may proceed in the same manner, when the middle lines are first drawn, but the end is better attained, if one begins with the clear opening of the upper polyfoil, lays off the midth of the moulding outside this and the adds the division arches.

Window with trefoil.

A window with a great trefoil and trefoil division arches below this is shown by Fig. 1235, the sections of the mullions being given by Fig. 1235 a.

The centres of the pointed arches may be at a and b. First are to be struck the concentric arches resulting from widths of the jamb mullions. Accordingly from a and b with the radius a b is made the intersection c, and from c with the radius a d the arch e f, in brief one constructs the circular triangle e f g based on the equilateral triangle, then bisecting the arches e g and f g and drawing through the bisecting points to the apexes of the opposite angles the straight lines a C and b C, the centre of the arches of the trefoil lie on these lines, and indeed according to the desired acuteness of the points h are nearer or farther from C. Then are struck the separate concentric arches formed by the bar section of the trefoil. Beneath this is added a round (left half) or pointed trefoil, (right half), so that at the narrowest places u o or p s the middle flat of the bar has its normal breadth.

Window with quatrefoil.

Fig. 1236 shows a window with a quatrefoil in its upper part, and the size of the quatrefoil leaves wide play, and here is assumed one of moderate dimensions. The section of the bar may have a round in front.

The centres of the pointed arch may be a and b, and the centre of the quatrefoil may be so assumed, that a c = c d, or in other words that a d is inclined at 45°. The radius of the centres of the four foils, which latter lie on the lines g f and e q equidistant frsm d, are to be chosen so that the quatrefoil has a beautiful shape, and at u is preserved at least the width of the jamb bar. According to the models of Fig. 1196 to 1198 is then taken the distance h i as the radius of the lower trefoil arch, and therefore this can be constructed on the line k k

as a middle line in the way that its inner curve touches the external one of the quatrefoil. For this purpose the distance h i is bisected and a vertical l m is drawn through the bisecting point. On the latter is sought the centre for the arch p q to be struck with the radius h r and touching the arch n o, so that this centre is true for the upper arches of the trefoil, while those for the lower ones can be found on the line h k, according to the acuteness of the points.

Fig. 1237 shows the filling of the space with the compound quatrefoil. Here to show a different procedure, the division arches are so constructed, and then increased by the breadths resulting from the cross section. Above is placed the quatrefoil and to this is adapted the enclosing arch of the window.

There is drawn the tangent a b to the outer side of the division arch and inclined at 45°, which cuts the middle line of the division arch at c. Then is laid off about a third of the distance d e on the line a b from c to f, a peppendicular f u is erected at f to a b, which is cut at g by the middle line of the division arch, and thus the points c and g are centres of the outer arches of the compound quatrefoil. If a circular arc is drawn from the latter, which touches the outer arches of the division arches, then are found the extreme points of the quatrefoil, that in like manner are drawn at all angles of the square a b v u. With equal radii are struck the short arcs of the quatrefoil in a skilfully appearing way. Care is only to be taken, that everywhere at least the full width of the flat of the umllion between the quatrefoil and the division arches, where it is not entirely injurious if the moulding concentric with the quatrefoil does not intersect that of the division arch, but extends beside the latter. The same is true in regard to the proportion of the quatrefoil to the pointed arch. The form of the enclosing pointed arch then in Fig.1237 is arranged according to that of the quatrefoil and its centres are found at o and p. But if the pointed arch must be struck according to the equilateral triangle, it would be difficult to avoid, that it would remain separated from the quatrefoil at its apex.

Another construction is shown in Fig. 1238. Here the ground lines of the pointed arch, whose centres a and b and the widths of the mullions are all given. The inner arches are first str-

struck from the points a and b, c b and c a are drawn, perpendiculars are erected at a and b, and make a d = b e = a b. then from d and e with the radius a f are struck the arches g h and g h′, which serve as first points for the quatrefoil composed of separate arches with equal radii. Under these are then placed the division arches.

Window with three trefoils.

Fig. 1239 exhibits the filling of the arched space with three trefoils. The centres op the pointed arch as well as the widths of bars are given. The regularity of the entire form consists in this, that the trefoils are similar to each other, that the apexes of the lower trefoils fall on vertical lines through t those of the division arches, and the three trefoils are in t the regular relation to the equilateral triangle to each other.

Therefore the centres c c′ must either fall on or below the base line of the pointed arch, according to whether its centres lie at d or are placed further inward. Hence there is sought, after the inner lines of the pointed arch are drawn resulting from the width of the mullion, the centre c in the manner that the inner trefoil passes through a, and cuts the middle line e e with a suitable apex. Symmetrical with c lies at the right of e e the centre c, and above both is c″ as the apex of an e equilateral triangle. Likewise is found the other points on t the large triangle c f g. The moulding is then extended around the trefoil and the point h is found, in which the flat or round of the member intersects the middle line e e on the outer limiting arch. Beneath it follows the trefoil division arches, whose construction can then be according to one of the preceding methods.

According to the measure of acuteness of the angle i and the width of the mullion, as well as the moré obtuse shape of the division arch it may be necessary, for the apex of the latter to lie lower than the point h. Then the centres k k are to be sought, so that the internal arches struck from c through h touch the round or the flat. Then either the first may continue beyond the point of contact toward the apex, or beyond it join the arch of the trefoil, so that a recurved point results for the division arch. Such ogee arches are already found in the traceries of Early Gothic; thus on the windows of the church at Haina. In the Fig. drawn the upper trefoil lies below the

corresponding jamb moulding of the window arch, but instead a also the entire tracery could be moved somewhat higher, so that here could be found a junction just as at the point a.

Allied combinations result in windows with three divisions. An arrangement of a window with three divisions similar to Fig. 1239 is found in a tolerably original condition on the c choir of the church at Wetter. Fig. 1169.

Window of three divisions with circle filling.

When a window of three divisions receives a great tracery circle, the middle division arch is placed lower than the two at the sides. Fig. 1240. To change this proportion there may be inserted between the circle, the pointed arch and the division arch an intermediate figure touching them, as in Fig. 125

The insertion of 5 pointed arches in the circle is effected in the following manner in Fig. 1240. A regular star with five points is drawn in the circle and the circle a a is described about C with the side of the inscribed polygon of 10 sides. T The intersectionsof this circle with the star at d d form the centres of the curves of the cusps.

A characteristic design results when the space in the arch is filled by a ground form based on the triple division, thus about according to Fig. 1235, where the middle division arch may have its apex below the opening of the trefoil as on a window of the sacristy of S. Elisabeth at Marburg, which is represented in the Gothic Musterbuch, part I, plate 6.

Window of three divisions with trefoil and trefoil arches.

The filling of the space by a compound trefoil is found in the cloister of the monastery of Haina (Fig. 1241). The centres of the pointed arch lie at a and b. First is struck the arches resulting from the width of the bar, then from a and b with the radius a b is made the intersection e, and from this is drawn with the radius a e the arch d e. In the curved triangle d e s is then inserted the tracery figure, and below it are placed the three trefoil arches of equal width with the middle one somewhat higher than the sides.

A very frequently occurring mode of filling the space is the trefoil shown in Fig. 1242. It is already found in the works of Early Gothic, as in the choir of S. Severi's church in Erfurt, but also reappears in the following period again frequently during the entire 14 th century, and is recommended by its

extreme flexibility.

In this Fig. the centres of the pointed arch lie at a and b. Then draw the arches formed by the middle lines of the outer flats as b f and c g, and there results from their intersection the centre C. Then draw the sides of the triangle located at a b c, here only given in the left half, thus f g, f i and then h i, there results by the point of intersection k of the last line with f b the radius for the circle struck from the centre C. The three tracery projections from the middle circle make a very different impression, according as they are made slender or broad. Here they are so formed, that the little trefoils in the remaining spandrels may have their centres placed at the dividing point f.

The mullion member lying at the basis of the entire form is that shown in Fig. 1229. The two trefoils filling the angles between the trefoil arches are only formed by the inner parts of this member.

The flexibility of the trefoil form shown in Fig. 1242 makes it particularly suitable for filling such spaces, that depart from the ground form of the equilateral triangle, so far as a diversity in the upper foil from the two lower ones does no injury at all to the effect. This difference may either lie in the length of the foils, as if c C were greater than a C, or in their direction if the point C is in the actual centre of the triangle, but is to be moved up or down according to the proportions of the space to be filled.

The origin of the entire trefoil form is to be derived from the wheel window, so far as it results naturally from a hexapartite wheen window by the omission of each alternate one of the arches enclosing a space.

Simple wheel window of the earlier Gothic.

The name of wheel window is to be limited in the strictest sense to those circular panels, which are substantially formed by radial mullions placed to correspond to the spokes of a wheel. These radial mullions stand with bases or without them on the circumference of an inner circle. The surface of the latter can be either unbroken according to its size, and then bear e either a relief or ornamental design, or it may be perforated and with a greater radius be beset inside by suspended arches. (Fig. 1246). In the simplest case the mullions have their cap-

abutting directly against the outer circle, or they are connected by arches of various forms, which either rest on the capitals or in lack of these spring directly from the mullions (Fig. 1243). The blind tracery without glass represented in Fig. 1243 from the still Romanesque church at Bellerbeck (Hase, Baudenkmäler Niedersachsens) shows the next development of a simple wheel window with columns radiating from the centre, that are connected by round arches and enclosed by a great circle. A d different form results if the columns with their bases stand directly on the outer circle as shown by Fig. 1270. The moulding of the mullions is the same as for all other windows (Figs. 1226 to 1229). Figs. 1243 to 1246 exhibit different similar wheel windows.

Fig. 1243 is based on the octopartite division of the circle. The mullions extend in uniform size (as in a,, wheel windows) from the middle circle to the outside and there branch into t trefoil arches, that are drawn pointed at the left and round at the right. The centres h and g of the latter lie at the middle of the bisecting lines a f and c g of an equilateral triangle.

For a greater diameter of the wheel the number of the mullions must be increased, i.e., instead of a division into 6 or 8 parts, that into 10 or 12 must be taken as a basis. Thereby the proportion of the length of the separate divisions or mullions will dominate, and it is preferable either to shorten t the mullions near the circumference or to arrange a transverse connection. Different ways for attaining the purpose first named are shown by Fig. 1244 in outline in its different divisions.

A frequently occurring wheel window is shown in Fig. 1246. Its construction is as follows.

After the division of the circle is made and the lines a b and c d limiting the breadth of the mullion are drawn parallel to the radial lines of the division of the circle, then is drawn the middle line e f of such a panel and in a side Fig. 1246 a line g h parallel to the latter. On this line as axis is constructed the trefoil at any desired size and the tangent k i is drawn parallel to a b. Now are drawn the lines n m, m c, c z in the side Fig. and then in the principal Fig., beginning at o the parallels o k, k q, q r, so that the centre of the trefoil is found in the main Fig. Below the point t of the trefoil

is then placed the trefoil arch, and indeed in this case, when t u is drawn at 30° with the line f b and from t is struck an arch with the radius t u, whose intersection v with the middle line is the centre of the lower arch touching a b and c d. With the same radius t u are drawn the upper segments of arches.

In the same manner could also occur the upper filling of the space a c by a quatrefoil, cinquefoil, etc.

This construction with a simpler division of the circle, as applied to one in 4 or 6 parts,permits the trefoil to become so large and its lower arches approach so nearly at the centre, that the radial mullions may possibly be omitted, as shown by the line x y in Fig. 1246 a, which corresponds to the radius in the division in 4 parts, the circle is then exclusively filled by the four trefoils, and the entire form passes from the wheel window more into the rose window. This is then a more complex form, where two rows of trefoils or quatrefoils are inserted in the circle, the outer one consisting of about 8 or 12 and the inner of 4 or 6, or where different figures are combined in the same way with each other as with quatrefoils in the outer row and as many trefoils in the inner one, or with trefoils in the outer and half as many quatrefoils in the inner one. Further variations are also given by Fig. 1244, if there the single arches connecting the mullions are changed to trefoils or other geometrical figures.

The combination mentioned above which the mullions of wheel windows may receive in order to reduce their length, can either be made in the manner, that the mullions extend through and the arches are turned between them, or that two systems of mullions are combined. In the last case either the number of separate divisions can be the same in both systems, and the mullions of the outer system stand on the crowns of the arches to the inner one, or the number of divisions of the outer system may be double that of the inner one.

A magnificent example of this kind is shown by Fig. 1245 taken from the cathedral of Minden. This wheel window is there not independent, but it fills the space of the pointed window arch in a very peculiar and perhaps unique arrangement. Fig. 1245 a.

Difference between the tracery of early and middle periods.

The tracery of the middle period differs from that of the e early period in this, that the latter consists of polyfoils

within each other or of simple ground forms, that only seldom have cusps, while in the middle period the polyfoils almost entirely disappear and the tracery is composed of geometrical ground forms, straight lines and arched, but which are nearly always beset by cusps. In the predominance of arched forms has been thought to be recognized a more structural character, and therefore the Early Gothic tracery is regarded as still undeveloped. It would be so if the curved sides of the different figures were actually arched, i.e., consisted of many separate pieces, in which case the jointeng would be made more difficult by the polyfoils. But in reality the origin of the tracery forms is not from arched construction, but is derived from the perforation of a stone slab, as clearly shown in the tracery given in Fig. 1169 from the church at Wetter. But accordingly the curved shape of the bars is nowise compulsory, but it can be replaced by any other straight or freely developed form. Therefore if a trecery consisted of one slab, then the freedom concerning the separate openings would only be limited, that the bars enclosing them should have the necessary size and connections. But if it consists of two or more slabs, care must be taken to have a suitable location for the joints between t them, i.e., that the joints must be placed so that each separate part rests on that or them beneath it, or extends between them like the separate stone in an arch. But these joints must necessarily cut the bars at right angles, thus being vertical for horizontal and radial for curved bars. But such direction of the joints is to be obtained without difficulty even in the least dimensions of the pieces in Early Gothic tracery, as they are represented in Figs. 1236 and 1239, shown by the joints marked s. On the contrary a comparison with Fig. 1247, which is a transformation of the scheme of Fig. 1239 and represents the style of the middle period, shows that the location of the joints is made far more difficult by the peculiarities of this style, by the growth of the curwes of the cusps out of the ground forms.

Accordingly there is a special consistency in the forms of Early Gothic tracery, in so far as they do not affect the pure arched form, where this has no structural importance, but on the contrary combine these and thus exhibit polyfoiled forms, which could not be employed with actually turned arches, but

are here the more in place. But further advantages result, as already noted above, for the treatment of the interspaces and finally for filling the window with glass paintings.

Simple tracery of the middle period.

The characteristics distinguishing the middle from the early tracery have been already explained, that this composed of polyfoils was entirely supplanted, and it is to be particularly deduced from this, that it afforded certain advantages for the treatment of windows in several divisions. Let Fig. 1231 be the scheme of a windou of four divisions, in which each of the two dividing arches are to be filled in the same way as the great pointed arch bn two smaller ones and a circle placed between them. Accordingly the upper circle b g will have a predominant sizel and hence in some cases a division of it would be desirable, which as already stated, may then be effected in different ways. On the contrary, if this circle were a trefoil (as in Fig. 1235) or a quatrefoil (as in Fig. 1236), then would a further division by possible only with difficulty, an so far as just these forms indicate the limits of divisibility.

Window of two divisions.

Each Early Gothic form is accordingly transformed easily into one belonging to the middle style, if instead of the polyfoil the corresponding ground forms of cusps are taken. Thus Fig. 1247, whose construction results from that already treated, accordingly corresponds to Fig. 1239, and thus the trefoil in Fig. 1235 would be transformed into the three arches with cusps and the division arches into pointed arches with cusps, and the quatrefoils in Figs. 1236 and 1237 into the four arches with cusps. The Fig. last named is particularly common and recurs in different proportions. Thus the four arches with their upper spandrels may either join the enclosing pointed arch or may be free from it (Fig. 1249).

The construction of the first case is the following. Let a b be the centres of the pointed arch, then erect a perpendicular to it, make a c = a b and strike from c the arch d e with a b as radius and also the arch d f. The four arches depend on the location of the centres a and b for the window arch. The closer a and b approach, the larger will be the four arches and the more are the division arches forced down below the ground line a b. The centres a b g c must always lie on the angles of a square

since otherwise the four arches would be distorted; in no case must it be reduced in width, so that e f is greater than d m, for rather should the converse occur. The construction of Fig. 1249 is then made in different ways, according to the proportion of the radii of the pointed arch and of the division arches to their spans. They differ from Fig. 1248 in this, that the four arches are independent from the enclosing pointed arch.

In like manner are employed the three arches for filling the space, and when this lower spandrel is omitted, it leads to Fig. 1250, in which the space a b c d shows a form allied to the fish bladder.

Simpler but less successful tracery results if the division arches are struck with the radius of the great pointed arch, so that the spandrel falls in the latter in like manner as the arc a b in the window with three divisions in Fig. 1260.

All forms heretofore shown gain in richness, if in each division arch is inserted a trefoil with cusps, Fig. 1251, beneath which is then a second pointed arch with cusps in the manner, that its vertex enters the opening, that is formed in the lower spandrel of the trefoil by the course of the entire tracery moulding concentric with the curves of the cusps, like a b c d e in Fig. 1247.

Window with three divisions.

Far more varied become the tracery forms of the window with three divisions. As the final form of the most common treatments of this kind may be taken Fig. 1252, which results from Fig. 1240 by the addition of two to the great pointed arch, circles touching the middle circel and the middle division arch. In Fig. 1252 the middle division arch is placed on the ground line a b of the great pointed arch, when the radius of the middle circle is easily found.

The entire form is extremely flexible, and therefore is just as well suited to every proportion of the great pointed arch, since the character of the whole can be modified by the different proportions of the circles to each other and according to the heights of the division arches. This diversity may be increased according to the number of the cusps inserted in each circle. Further the four arches may replace the upper circle, while beside them are either turned other circles or a trefoil as in Fig. 1253.

A simpler form is shown in Fig. 1254, whose condition results of itself, and all proportions of the arched space can be adapted. This is found especially common in brick construction, w where then in the simpler works the spandrel a b c remaining between the division arches is often but partly opened or is also left entirely blind.

In all these cases the division arches are in intimate connection together as with the filling of the space. But an entirely separate group is formed by those traceries in which the space forms an independent shape, beneath which the division arches abut with their apexes. In a sense Fig. 1255 already f forms a transition to the traceries of the last kind, and would be entirely counted with them, if the lower arch a b were entirely closed.

Very decidedly is the space of the arch isolated in Fig. 1255 a, which exhibits the skeleton of a window of four divisions from the cathedral of Erfurt, which otherwise is to be with the compound traceries (see above).

Likewise belongs here the form of Fig. 1242 very frequently occurring in the traceries of the middle period, and especially when the trefoil is also closed beneath by an arch.

Sometimes the form of the tracery on the old works also has required the ground form of the arch, so that its centres are placed beneath the ground line, when thereby is aided a complete development of the tracery. Such an example is found on t the church of S. Jacob in Erfurt (Gothisches Musterbuch, I). But already in the Early Gothic period were allowed such freedoms as are shown in the east window of the church at Haina, Fig. 1265, dating from the first half of the 13 th century.

Tracery of the Late Gothic style.

As we have already stated concerning the fish bladder, generally is expressed the character of the Late time in the dissolution of the geometric isolation peculiar to the preceding periods, thus making possible a freedom and diversity of forms far excelling the latter.

Fish bladders.

The forms of the Early and Late periods often still extend into the later, as then Fig. 1230 also occurs here as a scheme, so that only the filling of the space by the fish bladder is effected (according to Figs. 1213 to 1218). But more decided

are employed the latter, if with the omission of the circle t they fill the entire space as shown in Figs. 1256 to 1259.

In Fig. 1257 the centres of the pointed arch lie at a and b, so that b c = $\frac{c\ d}{4}$. The same propottinon is then also a basis for the division arches, so that also c e = $\frac{c\ f}{4}$. The perpendicular erected at b cuts the arch c g at h. With the radius b f is then struck the arch k h and the arch h l joining the division arch, so that the skeleton of the fish bladder is constructed and at the same time the ogee curve h l replaces the division arch. After then the ogee h m is found in the same manner, the concentric arch resulting from the plan of the mullion can be struck and the cusp be inserted.

A freouently repeated flexible motive is shown in Fig1256. This comes substantially from the filling of the space remaining over the semicircular division arches by two circles about the centre a, which are tangent to the middle line of the division arch and join above the arch e c. When no break occurs, the transition point e must lie on a line with the centres a and k.

The same scheme could also be employed for a window of three divisions as shown in richer form by Fig. 1259.

In it a andb are the centres of the pointed arch. On this g ground line are struck the semicircles a l and t b, and also the circle about c tangent to the latter, the great pointed a arch and the middle line, and further with the radius of the latter the arch c d forming the enclosing pointed arch as well as the arch c e forming the first semicircle. Then draw the line c f at an angle of 45°, and from this intersection with the circle strike the arch g h, which goes through the centre c and joins the pointed arch, as well as from a point k to be found, strike the arch i f tangent to the circle, thus is found the skeleton, and the further execution has no further difficulty according to what has been stated.

To the German forms of the fish bladder correspond those of the French flamboyant style, of which we give an example in Fig. 1258 taken from the central tower of the church of S. Maclou in Rouen. The difference between the two kinds is to be sought chiefly in this, that in the French tracery the fish bladder moves more in one direction, and thus comes nearer the form of flames, while in the German this movement occurs from

the middle outwardin any desired direction, and so more varied motives certainly became possible. In contrast to both continental forms are the divisions of tracery corresponding to fish bladders or flames in the English perpendicular style, that represent entirely similar diminutives of the spaces enclosed by the mullions and division arches, they extend always in the same direction as those, and so fill the space of the arch in a tolerably uniform way, but produce a rich impression.

Intersections.

We have already stated above, that after the ogee curves it is particularly the intersections which characterize the tracery of the Late Gothic. Though it often occurs in the second half of the 15 th century, that the division arches intersect, while the mullions are connected by a semicircle with the omission of one lying between them, from whose intersection results then t the pointed division arch (Fig. 1261). Another filling of the space may occur by a circle, quatrefoil, etc., with fish bladders next them or solely by the fish bladder in that given in Fig. 1261, an example taken from S. Martin's church in Cassel appears a special consistency, so far as the depressed pointed arch filling the space is formed by two intersecting ogee bars and only in the fish bladders formed at the sides is a cusp inserted in the middle. certainly the scheme given in Fig. 1260 belongs here, to which reference was made already on p. 523, w while here the effect of the intersection of the part c b of t the arch with the great pointed arch is far more tasteful, than that of the semicircles in Fig. 1261 with each other, even if here a certain dryness is also undeniable.

4. Tracery of compound mullion and wheel windows.

Plan of compound mullion windows.

Connection of large and small mullions.

Already in the earliest Gothic, beside the simple tracery windows occur compound ones, which are then formed so that in the parts of a simple large system of tracery are always found a smaller secondary system, or an inverted system of the second order, as indicated in Fig. 1262 by the heavy and thin lines. The mullions and bars of the inserted second system have a correspondingly more ornate cross section, and they are termed "y "young" mullions in contrast to the "old" or principal mullions. The small mullions are partly isolated (a aud b in Fig. 1262)

ard are partly attached to the principal mullions or jambs (c d in Fig. 1262). The cross sections of the principal mullions must also be so arranged, that the smaller develop from them as if they were born from them.

Already in the simple tracery beset by cusps, as we have further seen above, the cross sections of the cusps were expressed in the mullions, and similarly but even far more expressed must be the cross sections of the small mullions be contained in those of the larger ones. If in a window with large and small mullions occur cusps at the same time, then the principal mullions will even contain three different profiles and the small ones will have two. In Fig. 1263 accordingly a d g h will represent the larger and b d f i be the smaller mullions, c d e x representing the cusps.

Nowise is the possibility excluded of moulding the mullions relatively richer, for example for a simple tracery with cusps employing the entire frofile in Fig. 1263, thereby giving the cusps the richer moulding b d f i, and on the other hand simplifications of the cross section are also possible.

One can further establish the principles mostly followed in the early time, that only those parts make the compound plan necessary, in which the elevation is actually compound, also t that the plan of the bars according to the spaces with cusps could or must be different,from those employed for spaces without cusps or for division arches, as we have already explained in regard to the Marburg window. For such an apparently complicated but naturally a simpler arrangement, the magnificent windows in the transepts and choir of the monastery church at Haina (Figs. 1264, 1265) present the most beautiful examples.

For the former Fig. 1264 a shows the plan of the half of the mullions and bars next the interior. Therein a b c d is the half plan of the large mullion, which includes that of the small mullion b c d. The division arch without cusps has the same plan as the small mullion, and it also continues in the circle above it, only that on the inside are added cusps, whose plan is indicated by c f in Fig. 1264 a. To strengthen or fill the moulding projects before the junction of the cusp in the lower circle w with the part denoted by g, while this is wanting in the great circle, so that the cross section through the great circle on a f is a b c.e f in Fig. 1264, and on b f through the small

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circle is b g e f in Fig. 1264 a. Since now in the lower divisions the plan becomes more complex, it is again simplified there, where the divisions in the elevation become greater, as in the spaces between the great pointed arch, the upper circle anf the arches enclosing the groups, here taking the form a b i k, so that between the elevation and plan occur the most intimate and alternate relations, and in all down to the smallest part, the finest distinctions are emphasized by the spirit ordering the whole. But this enhanced consistency did not allow the internal tracery mouldings to be employed externally, where on the one hand beside the larger forms of all parts the finer mouldings would have been without effect, but on the other hand just on the north side would have presented too many starting points for the effect of weather.

In Fig. 1264 b is shown the external mouldings in such manner, that a b c d the members of the large mullions are continued on the great pointed arches, as well as on the exterior of the division arches and the bars enclosing the upper circle, e b c d is the moulding of the small mullion here without capital, which continues in the same form on the inside of the great division arches as well as on the exterior of the lower circle, while t the internal side of the latter with its cusps is formed according to f g h c d, so that g h c d becomes the plan of the cusp. On the contrary, richer is the form of plan of the inner side of the moulding on the upper circle according to a e i k l m n c so that here k l m c d becomes the plan of the cusp. A similar distinction of the outer from the inner mouldings of the tracery is then also found on other windows of the same church.

The capitals in Fig. 1264 only serve to indicate the beginnings of the arches, and therefore are also found in their actual main lines. In the east window of the same church given in Fig. 1265, they fulfil the same purpose of adjusting the simple plan of the mullion to the more richly formed plan of the division arches. While in Fig. 1265 a, a b c d e is the plan of the large mullion as c d e represents that of the small one, for t the reasons given above the division arches receive an addition by the member f, which as shown in Fig. 1265 b in perspective, is set on the capital at a a in Fig. 1265 and also extends around inside all spaces beset by cusps. The cusps here have a form of section still recalling the forms of the transition style,

while they lack all moulding and simply project as fillets, thu also expressed by d h i in Fig. 1265 a.

Simplified pan of mullions.

As already noted on p. 507 above, there result simple plans of mullions, as soon as the development of the cusps shown in Fig. 1183 is allowed. Accordingly the plan shown in Fig. 1267 a was sufficient for a compound window, if the cusps received the plan indicated by hatching in the right half of the Fig., so that also the hatched part in the left half becomes the plan of the small mullions and the entire Fig. that of the large ones, as it is found on the west window of the church at Haina given in Fig. 1267. But this omission is even increased and the leads to further simplification of the plan, and finally to Fig. 1267 b, in which then m f g i k gives the large mullion, that is only distinguished by an increased depth from the equally thick small one m e c i k, as also w i k further gives the plan of the cusp.

Likewise as on the large mullions there is attached to the jamb mullions half the plan of the small one. Yet are also found many varying conditions, especially in the works of Early Gothi to which that stiffness is still foreign.

Doubled middle mullion.

Thus in the windows in 4 divisions of the north side of Strasburg minster the middle mullion consists of a doubling of the jamb mullion, so that the small one in Fig. 1267 c are shown b c d the small mullion, b c e the jamb mullion and b c e f is half the middle one, that accordingly consists of two little columns connected by a hollow. On the contrary on the older parts of the cathedral at Wetzlar the jamb mullions are entirely lacking and the division arches grow directly out of the jambs lying in the direction of the thickness of the wall, in whic must therefore be cut the groove to receive the glass panels. This arrangement still recalls the starting of the arches of so many Romanesque cloisters, where the growth of the arches is already clearly expressed, but at the same time shows in principle a striking agreement with the arrangement mentioned on p. 507 of the tracery of the Late Gothic castle chapel at Altenbur

Development of the elevation of compound tracery.

On the laying out or drawing the compound tracery, it may onl be stated, that it is just as complete as in the simple tracery

(See above). One passes out from the middle line of the mullion or bar and covers this by the profile, whereby the large and jamb mullions have several parallel lines for the large and small members (c, d, e, in Fig. 1262).

Window in 4 divisions.

The simplest arrangement of the window with 4 divisions is t that based in the scheme in Fig. 1262, of which Figs. 1264, 1265 give two specimens, which date from the same period but are far apart in their effect by the difference in treatment. This diversity is increased to infinity by varying proportions of different parts and a varied arrangement of the other filling, and according to what has been previously stated concerning simple tracery and filling circles, it will not be difficult to find new combinations of this kind.

Windows in 4 divisions with three groups.

However men already began about the middle of the 14 th century to seek variations , and first to make these possible by transferring the peculiarities of the window in 3 divisions to that with 4, forming three groups, the middle one consisting of two spaces, at each side of which remained one space, as the c choir of Erfurt cathedral shows in a rich series of examples. This arrangement is connected with the fillings in the spaces shown in Figs. 1240 to 1242, 1252 to 1254,but always injures in a certain lack of clarity and purpose that simple arrangement characterizing the nature of the matter as opposed ho Figs. 1264 and 1265, but on the contrary this inequality of the divisions forms the natural arrangement for tracery in an unequal number of spaces.

Windows in 5 and 7 divisions.

Hence tracery in 5 divisions can consist of three groups, namely of two double divisions separated by a single middle space, and one in 7 parts may likewise consist of three groups, indeed of two triple divisions separated by one single space, or of a triple division in the middle and two double ones at the sides, whereby the filling of the space is always one allied to the triple division.

The single space between the groups composed of two or three divisions is then enclosed at both sides by large mullions, which remain as division arches above, but sometimes are without the moulding characterizing the large mullions. But thereby also

the division arches will be ineffective, and the filling of th space by the latter is no longer sufficient, and makes the eff ect have a certain heaviness. Generally a tracery in 4 parts arranged in the manner mentioned, where including the jamb mul lions are found four large and but one small mullion, lacks bu one more step to the Late Gothic, being without all main and lesser subdivisions, thus being a window consisting of entirel similar spaces and mullions.

Window in 6 divisions.

Just as here the characteristics of the arrangement of the w window of three divisions is combined in a capricious way with that in two divisions, this combination becomes natural for tr cery in 6 parts. That either consists of two groups of three d divisions each, or three groups of two divisions in each, so that in the first case the main arrangement of the whole corres ponds to that of the window in two divisions, while in the last case the converse condition exists. The first arrangement is found on the west side of the Gologne cathedral according to t the original design, while the latter is by far that generally prevailing and is found on the west front of S. Elisabeth in Marburg, the collegiate church at Mantes and the church of the monastery of Haina. The two examples last mentioned are repres ented in Figs. 1266 and 1267.

The extremely rich window at Haina belonging to the first ha of the 14 th century is in striking contrast to that represent in Figs. 1264 and 1265 from the same church and belonging to th 13 th century, which illustrate the superiority of the tracery about a century older to that of the extreme richness of that later.

There is found in the drawing of the earlier window in Figs. 1264 and 1265 the clear arrangement and the wise restriction o the ornament of cusps to certain spaces, which thereby fully d dominating the whole, contrasted with the uniform spreading of this ornament over all spaces, which is peculiar to Fig. 1267, so that this condition comes more into the light where the sim ple treatment of the older window with its surrounding archite tural details of rounds, side arches and vault ribs, remains i the most beautiful harmony, and the entire surface of the wall imparts a higher life, while the richer form of the west windo is entirely loosed from its surroundings, its effect is restri

restricted instead of being increased. It is further to be well considered, that such window tracery is not there for itself, but at the same time is to serve as a framework for the inserted glass panels, hence must therefore be paid to the glass painting that covers this filling, to afford for this a not too restricted size and form. All these requirements are satisfied by the tracery in Figs. 1264 and 1265 in a high degree, while the uniform predominating later with cusps inserted everywhere offers restricted spaces, and thus is certainly less on the whole than by its own will. Then the glass-worker toiled to master this hindrance, and in these small and limited spaces to insert even overrrich figure and ornamental representations scarcely to be distinguished from below on account of their small scale, making the disadvantages even greater with all the beauty of the glass painting. This existence for self alone is more peculiar to modern art, and appears generally to be increased with the overrich tracery of the middle period. Men began to place an extreme importance on it, as already the epitaph of master Reinhold of Altenberg shows, by whom the great west window was completed in 1398, in which he is called "above all the king of stonework". But that Gothic art required rich tracery in a degree far less than is usually assumed, is proved satisfactorily before all by the simple windows in two divisions of the cathedral of Chartres, whose overpowering effect would only have been lost by richer tracery, since the wonderful glass paintings must have been restricted thereby.

As a true model of a simple and still rich arrangement can be taken the window of the north side aisle of the collegiate church at Mantes given in Fig. 1266, which is probably later than the church, and that must date from about the middle of the 13 th century. The plan of the mullion is represented in the right half of Fig. 1266 a.

The construction is simple and as indicated by the lines. The ground line of the arch is a b, its centre lies in the middle line of the side divisions, thus in the points c. At the point c draw a line at 45° with the ground line, which gives the centre C of the trefoil at its intersection with the middle line of the window. From the point C draw the line C e at an angle of 60° with the middle line, erect a perpendicular at the point f, found by dividing the ground line into three parts, which

cuts the line C c at g and thus gives a centre of the trefoil arch, from which the others can be found in the same way. The possibility of the further very original detailing of the trefoil then depends on the width of the moulding, so far that at h i must remain at least the width of the small mullion.

Window of 8 divisions with 3 systems.

As the arrangement of four divisions comes from that with two, so is developed that of tracery with 8 divisions from that of four, it is merely a multiplication. But there are permitted by the size of the space certain richer treatment. Fig. 1268 shows an example from the north transept of the cathedral of Meaux, that entirely corresponds to the scheme of Fig. 1262, The construction is given in Fig. 1268 a.

Bisect a c at d, which distance results from the division of the ground line into 8 parts, so that d is a centre of the pointed arch, whose ground line is also that of the arch f g h, whose centres lie at f and g.

Then lay off a c from a to e and draw a horizontal through e, which is the ground line of the arch k e, etc.; then draw e l = $\frac{a\ g}{4}$ from e to m and draw through m a horizontal, which gives the ground line of the little division arches. Accordingly the different spaces spanned by circles are easily constructed, the widths resulting from the plan are laid off and the cusps are inserted. But the plan is shown by Fig. 1268 b. The filling of the upper circle is constructed as follows; a b in Fig. 1268 is half of c d, and the centre of the arch a b d on the line a b is about a quarter of its length toward the inside, thus moved to e and f, whereby by dividing the circle in 6 parts the rest results. We give here only a possible construction of this tracery, which we cannot entirely determine whether it accords fully with the actual one.

The advantages of this tracery have been already emphasized in Figs. 1264 and 1265, and these would be compared with the far richer west window in 8 divisions of Altenberg in the same manner, like that in Fig. 1267. A varied arrangement of tracery in 8 divisions, which corresponds to that shown in Fig. 1254 f for the window in 3 divisions, as shown by the west window of the church of the Minorites in Cologne. Its eight divisions are arranged in three groups, the middle one including four spaces. While then the two arches of the side groups stand on the ground

line of the pointed arch, the middle one is higher like the middle space in Fig. 1254, and the vertex of the enclosing arch abuts beneath that of the great pointed arch. The peculiarity of the arrangement results from the depressed proportion of the entire window, that is avoided by the higher position of the ground line of the middle arch. It shows at the same time a certain relation to the form of the window of the choir of Erfurt cathedral mentioned on p. 528, but far excels the latter in pure c caprice, as results from the basal proportions.

Windows of 9 or more divisions.

Windows in 9 divisions as in the cathedral of York, can be arranged in three groups of three divisions, thus being referred to the principle of three divisions, while one in 12 divisions is formed by a complication of the system of that in 6 part

Uniform mullions of the late time.

Differently from the principles stated are formed the richer combinations of tracery of Late Gothic. In the once adopted forms of ogees of fish bladders had men found the means for directly filling any form of space. Any division into main and s subordinate parts would have hindered the unlimited development of these means and was therefore dropped. Accordingly all mullions receiwed the same form, are connected by round or pointed arches, and the latter cling to the fish bladders with unrestricted variety, that are either arranged in groups without these being enclosed by wider bars or independent from each other, t they alone fill the spaces by their artistic interlacings. If in all these the complete dissolution of the Gothic organism is made perceptible, then must one be surprised by the inventive gift, the skill in arrangement, and the taste in the entire treatment. These are the last rays of the sun setting behind the mountain, for which the artificial light then kindled showed itself as a miserable substatute.

Compound wheel and rose windows.

Mullions placed radially.

The principle of compound tracery is also followed by the great wheel and rose windows. Their simple forms were already explained in Figs. 1243 to 1246. From what was there stated will be easily developed the forms shown in Figs. 1269 to 1271. The predominating magnificence of these windows, attainable by no other means, such as the minster at Strasburg as well as that

shown in Figs. 1269 to 1271. The predominating magnificence of these windows, attainable by no other means, such as the minster at Strasburg as well as that shown py most of the French cathedrals, needs no commentary. It has been attempted in modern times to wish to find these in contradition of the true principle of Gothic, but it appears to us unjustly. To exclude them would be to rob one's self. They either occur independenlty on the French cathedrals or are inserted in a pointed window of ordinary form with a straight sill. The arrangement of the sill, which is also generally found where the pointed arch is wanting and manifests itself in the manner, that the deeply moulded soffit arch enclosing the upper semicircle is continued at each side in the vertical jamb or rests on little columns and stops on the wash of the sill, happily removing the possibility that the water could collect in the mouldings extending on the lower semicircle, and brings the entire treatment into complete harmony with the other lines of the interior and exterior. It is already found in works of very early date, like the collegiate church at Mantes, the cathedral of Rheims, the transepts of the cathedral of Paris, etc. But now since the upper semicircle in the interior is inserted within the pointed arch of the vault, the latter may also be expressed on the exterior, and then produce the arrangement of a rose window in a pointed arch before criticized by Kugler, which still has its full justification as being based on the nature of the construction. On the other hand to us appears that transferred from the west facade of Freiberg cathedral to many later works, less happy in the stronger accenting of the enclosure of the circle within a square, since then the upper side of the square in this place is given by no conditions, and therefore represents an arrangement purely based on caprice. (In Freiberg it is connected with the horizontal roof of the narrow passage before the western cross arch and therefore is well grounded). Then whether such an untrue form can be actually found beautiful may be left to an open decision.

Radial divisions.

In many late wheel windows, like that of the west facade of S. Lorenz in Nuremberg (Fig. 1271), the radial position of the mullions is dropped and is only retained for the divisions formed with parallel sides. The entire scheme consists of two intersecting crosses, each arm composed of two divisions, therefore

being a part inclosed by large mullions. The pointed arches connecting the latter then in one cross have their vertices in the outer circle, and in the other in the angle of the arms of the first cross.

A position intermediate between both arrangements in Figs. 1 1269 and 1271 is taken by one of the wheel windows of the church of S. Katherine in Oppenheim, where the circle is first enclosed by a quatrefoil, each part of which consists of two large and one small mullion, but all are set radially. But between t these four divisions are placed four others, in which only the middle line is radial, and is indicated by a small mullion, which is parallel to the enclosing large mullion. The pointed arch connecting the latter is turned toward the centre, and thus joins the large mullions of the quatrefoil.

Geometrical figures within the circle.

According to what is said on p. 520 on the simple wheel window and on p. 511 on the filling of a circle, it cannot be very difficult for a third kind of rose window to construct the different examples, in which the entire area is enclosed by differently shaped and more strongly profiled bars, and filled by inserted geometrical figures bordered by weaker bars, such as circles, trefoils or kuatrefoils, etc., in the different areas. Yet for their effect such rose windows remain subordinate, consisting at least in their main parts of radial mullions and spaces, if already for the technical execution, the differences resulting from the great length of the mullions are to be avoided.

5. Balustrade tracery.

Balustrades with mullions.

Construction of the railing.

On the construction of the parapet, that is further more fully explained on p. 363 above in connection with gutters and drips, there will be here mentioned only, that the tracery balustrades consist of separate slabs 15 to 20 cm thick as a rule. If possible they are made of one piece in height, so that the separate pieces meet at their end joints and at the base by the moulding on which they stand, but are connected together at top by the rail laid on them. Hence the joints in this rail alternate with the joints of the slabs and receive in grooves the tongues wrought on these slabs. Where the required height is hard to obtain, they consist of two pieces separated by a bed joint

as on the church of Friedberg, and therefore must have greater thickness so that iron dowels, by which the bed joints are connected, can be held by the mass of stone enclosing them. The thickness is 22 cm at Friedberg. Instead of the stone tongue t that enters the groovein the rail, the connection is sometimes made there at iron pins, as on the balustrade surrounding the terrace on which rises Erfurt cathedral. From the once assumed thickness of the slabs results then the width of the mullions or bars of the tracery according to the size of the openings required by the scheme adopted.

The cross section of balustrade tracery agrees with those of window tracery, except that the groove in the latter for receiving the glazing is omitted. Therefore results the form of cross section given in Fig. 1272. Frequently is found the diagonal square in the thickness of the slab, also the octagon formed from this as well as the earlier shown simple plan of the mullion.

Mullions and little columns.

The simplest arrangement of a tracery balustrade consists of a row of mullions connected by arches. The feet of these mullions are then connected by a horizontal base left on the slab. To the arches applies what is said of the division arches of window tracery; they may be simple round or pointed arches or with cusps, or may assume any trefoil shape. They become richer if in the spaces remaining between the arches are inserted circles, trefoils, etc., as shown by Fig. 1273.

The advantage of these mullion balustrades lies in the easily understood scheme, in the fact that the small width of the spaces permits a frequent repetition, and thereby produces both a rich and a quiet effect. If such a balustrade stands on a stair the mullions likewise retain their regular form. Every attempt to depart from it, i.e., to form rampant arches is foreign to the nature of the matter, and the raise corresponding to the r rise of the stairs can be produced only by stilting the arches.

The verticals may also be formed as little columns, when the railing is made in the same slab as the balustrade, whose thickness therefore suffices for the capital and base. In the othes case this projection would be entirely useless, to require the thickness to be dressed off for the entire height of the slab. The latter would be superfluous when the mullions assume the forms given in Fig. 1272 a, thus consisting of two little colu-

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little columns connected by a mullion without capital. In such arrangements are very effective means for producing a rich effect, yet this must stand very near the eye, in order to be perceived at the small scale.

Height of balustrade.

The height of the balustrade is necessarily arranged according to human height, so that the top rail may come at the usual height of a parapet, thus from 1 to 1.2 m, yet there are also exceptions from this. Thus the roof balustrades of Cologne cathedral are about the height of the shoulder of a man, and those of the cathedral of Rheims are more than a man's height, so that we can only look through its openings. An inconsistency cannot be found in this, since the ordinary height of a balustrade is fixed by the convenience of leaning on it, but this respect fails in a roof balustrade, that merely forms a wall to protect from falling, which therefore on great works may very well assume the character of an arcade. According to this greater height the thickness is also increased, and the entire balustrade may be subdivided with large and small mullions like windows in several divisions, and like the upper balustrades of the cathedral of Cologne. A similar treatment for smaller dimensions would only be permissible in purely ornamental architecture, particularly on internal structures like altars, tabernacles, etc.

Tracery balustrades proper.

Polyfoils arranged beside each other.

The entire arrangement of mullion balustrades was originally based on a construction differing from the perforation of a stone slab, whereby the columns or mullions were peaces cut separately, that were longitudinally connected above by the arched pieces and below by the sill or directly by the slab on which they stand. (Note). But evidently the perforation of the slab leads rather to a form of tracery consisting of polyfoils, circles, quatrefoils or other ground forms.

Note. Some examples of this kind are found in the Dictionary of Viollet-le-Duc.

Fig. 1274 shows a balustrade composed of trefoils placed beside each other, and Fig. 1275 has one of triangles with inserted cusps.

By changing the position of the forms, by the introduction of the trefoil in Fig. 1274, By insertion of cusps in it, by inclosing

it by a circle, etc., or by connecting the motive indicated with another, and further by the repetition of the scheme in two rows over each other may be produced an infinite variety.

Fig. 1276 shows a balustrade composed of quatrefoils, which is contrasted in Fig. 1277 with a corresponding form of squares set diagonally and beset by cusps. If already the treatment shown in Fig. 1276 is more peculiar to Early Gothic works, it is sometimes found occasionally about the middle and end of the 14 th c century, as for example on the roof balustrade of the church at Friedberg and the Wiesen church in Soest. Peculiar combinations further arise by the alternation of horizontal and diagonal squares as shown by Fig. 1277 a. In both Figs. 127/ aod 1277 a t the skuares are replaced by quatrefoils or square openings with cusps, as on the west facade of Cologne cathedral. Particularly characteristic is the occurrence of the apex of the square or quatrefoil in the opening between the arches of the cusps or of the quatrefoil as in Fig. 1277 a.

A substantial change in the effect of the tracery is obtained if any single figure is enclosed in a square, so that thus in Fig. 1176 the quatrefoil and in Fig. 1176 the lozenge are separated from each other by vertical mullions. These latter may then have a greater width, so that the end joints of the separate slabs pass through their middles, while then usually occur in the diagonals of the separate figures. Here as in the window tracery it is first of all essential for the joints to cut the bars as nearly as possible at right angles, thus that all acute angles, all projections of certain weak points in the joints be avoided, since the latter result if the joints are cut through near the middle of a cusp.

Late balustrades.

From the transformation of the square in Fig. 1277 into a quatrefoil results sometimes occurring in Late Gothic works a continuation of the arches to the upper and lower horigontals as shown by Fig. 1278. Otherwise is characteristic for the balustrades of Late Gothic most of all the increased use of the fish bladder motive, and the possibility of the most astonishing combinations thereby produced. These fish bladders are inclosed in either circles or other ground forms, or they fill with their varied interlacings the entire surface. In spite of the lack of easy understanding peculiar to these forms, their effect is still

generally extremely magnificent.

But an increased interest is attached to them, since they represent the transition of the Late gothic foliage friexe. Thus with less transformation could be made a foliage frieze from a Late Gothic tracery frieze, or the converse; hence both are usually found connected together. Thus the greatest diversity of the separate forms in each species leads quite directly to the transition of the separate species into each other, and hence variety in details to uniformity in the whole. Perhaps accordingly one would not fail, if in the design of new forms of any kind, in any material, when everything possible is avoided, that could easily be transformed into another material, another species, since it is the generally hardest problem to conceive the character of every part as sharply as possible, and to represent it as clearly as possible.

Late Gothic tracery balustrades are found in great numbers in all provinces of Germany (Kallenbach's Chronologie). As for the best examples are to be considered indeed those in which a are still indicated the enclosing forms, even if broken and not fully developed. A very beautiful balustrade of this kind is found on the former organ gallery of S. Severi in Erfurt on the east wall of the north transept (Fig. 1279).

As a single example of this kind may this construction find its place here. The entire scheme is based on a network of equilateral triangles c x k, k b s, etc. From the points a, b, c are struck the circular arcs d g v e, f i n g, etc., and from the points h i k, the arches l m, n o, p q, etc.; thus draw in all triangles the bisecting lines r s, r i, a k, a t, etc., place the compasses on u and open them to the arch l m and carry the circular arc to v. Then from v with the same radius make the intersection w and strike from w the arch v u, thus by repetition of the procedure is constructed the entire skeleton, and it is only necessary to cover it with the width resulting from the cross section and to insert the cusps to complete the Fig. The junction with the vertical side of the enclosing rectangle is made as follows. With the radius of the great circle, thus with q k, strike from a point on the produced middle line the arches belonging to the sides x c and y c of the triangle, and place in them the ogees z z.

Blind balustrades.

Blind tracery balustrades are formed in the same manner and permit a lesser thickness of the bars and accordingly a more c complex plan of the scheme. Concerning the plan of the mullions (if the blind balustrade like Fig. 1263 is to be formed) it is to be stated, that the effect in the mass is more pleasing when it boldly projects from the ground, as if with chamfers or coves that intersect behind the mullions, or when the space bordered by the mullions is formed as a flat segment.

We shall again collect briefly all to be taken into consideration in the design of a balustrade.

Requirements in a balustrade.

1. The entire height including the rail is determined according to the purpose of the balustrade, the place where it is located, and within certain limits (as in Cologne and Rheims) also according to the dimensions of the building.

2. The thickness of the slab is generally determined according to its height and as a rule amounts to 1/5 to 1/7 of the height.

3. The form of the tracery and the development of the scheme depends on the height of the position, on the unbroken length, and on the dimensions of the adjacent parts. Therefore the scheme must be entirely recognizable from below, be so often repeated that it becomes easily understood, and differs somewhat from the dimensions of the adjacent forms of tracery in the intersecting gables or pinnacles by either greater or smaller dimension. The length of the balustrade here comes so far in consideration, that the termination of the tracery at the end may be clever.

4. The ground of the bars of the perforated tracery is arranged according to the thickness of the slab, the scheme of the tracery and the nature of the materials. The width of the bars may be to the thickness as 1 : 1 or 1 : 2. The choice of cross section depends on the greater or lesser simplicity of the scheme. The width of the bars is best in the same proportion to the width of the larger openings as that of the thickness of the slab to their height. The nature of the material is so far an influence, as a too hard as little as a too easily weathered stone permits a small size of the mullions and bars.

6. Gable tracery.

Tracery of window gables.

Gable tracery is chiefly used in the so-called window gables, and there fills the irregular spaces remaining between them and

the arches of the doors and windows. If the ashlars composing the masonry are bonded in the wall, then the tracery is blind, i.e., perforated; but if the window gable stands free before t the face of the wall or balustrade, the tracery is perforated and bears the coping, and its scheme as well as the jointing of the separate pieces must be formed according to this structural purpose.

The nature of the space to be filled leads first to the scheme of triple division, and thus to the trefoil (Fig. 1280). If the triangle on which the latter is based stands with its vertex upward, then if the direction of the apex of the gable varies from the sides of the equilateral triangle, either the trefoil is s separated from the gable as in Fig. 1280, or an irregular form must be assumed. Instead of the trefoil may the filling consist of a kuatrefoil placed horizontally or diagonally.

With greater dimensions the height of the vertex of the gable above the trefoil or quatrefoil may be too great to do without further support. The same condition also then occurs in regard to the two lower spaces a b c, it is nearest to further divide the space remaining by other inserted forms of tracery. Such a skeleton arrangement is taken from the southwest portal of the cathedral of Rheims as shown in Fig. 1281, that indeed can give no idea of the high magnificence of the French original, how the great spaces are filled by rosettes, and before the middle one stands the statue of the interceding Maria, toward whom the saints in the adjacent gable turn. A similar arrangement is found in the west portal of the church in Cologne.

A different filling results from vertical mullions connected by arches, their feet standing on the outer line of the arch, as on the high altar of the church of S. Elisabeth in Marburg. The skeleton of such an arrangement is shown in Fig. 1282.

A very suitable form of tracery for these gable spaces is given by the trefoil contained in Fig. 1242. By its peculiar flexibility it is particularly adapted to be added to all forms of these spaces varying from the shape of the equilateral triangle. By the use of large and small mullions, the last of which divide again each part of the trefoil in two or more spaces, by the insertion of other figures in the spandrels remaining between the different parts, the effect may be enhanced to the highest degree, as before all is shown by the cathedral of Cologne.

A construction usable generally, on account of the changing proportions of the apex angle, of the gable and of the radii of the pointed arch, is impossible and only an abbreviated method of trial varying in each separate case can be employed, some starting points of which are given in Fig. 1283. Let a b there be the slope of the gable and a c be the outside concentric arch of the window. It is next to find a favorable centre g for the entire trefoil, and it is best chosen so that a circle can be struck from it, which at the same time touches the crown of the arch and the line a b. The three tracery foils projecting from the middle may have wide or narrow proportions; they can je so determined that in the spandrel a c d is sought an inscribed circle with the centre e, and from the point of tangency g is struck the arc i h so that it is tangent to the line a d. With the same radius is struck the other arc i m. In the upper spandrel is assumed the same pointed arch p o q. From k is struck a circle with a radius of half g h, in this is inserted a trefoil, and then is drawn the trefoil arch and the pointed arch m i h or p o q and at the same time the tangent lines p r, r h, etc. Thus is found the skeleton of the trefoil. This can accordingly be covered by the widths resulting and be further executed with the inserted cusps, or in greater dimensions be developed in a richer form. At the end might be inserted between the three divisions either the circle u or other forms and accordingly regarding the entire form as the skeleton of the large mullions. Each of the three divisions may then be divided by small mullions, whose middle lines are represented in v w, x y, and also the circle u be subdivided by inserted figures.

In the original elevation of the west facade of Cologne cathedral the filling of the gable above the upper sound opening of the tower is in a certain sense opposed to what is stated above, while the three great tracery arches of the spandrel are turned toward the centre of the gable area, in which they meet the spandrels, so that each of the three spaces assume the form of a colossal fish bladder. The further division by small mullions and tracery forms still heighten the appearance of the fish bladder.

In the later periods of Gothic art, in which the form of the fish bladded had come into general acceptance, the rectilinear window gable was almost generally supplanted by the ogee arches,

the so-called ass' back, which in the lower part bent close to the arch and therefore left an open space between them for the filling tracery. They are then found to be filled less with tracery than with foliage, figures or symbolical representations

Tracery in great gables.

Tracery in the great gables of the transepts, of towers and of private houses, is already found in the earlier time, it consists of division mullions connected by tracery, of great roses, trefoils or of smaller geometrical figures, that extend uniformly over the entire surface. Especially peculiar are the gable fillings composed of moulded bricks on many brick structures, which already occur in a very early time (Ratzeburg, Colbatz in Pomerania, and Riga) and finally continue in the Renaissance. Some particularly rick examples of such later gables are afforded by Stargard in Pomerania in its city hall and some private buildings.

1. Arches and Jambs of Doorways.

Simple members of arches and jambs.

Note. See examples of the Gothic period in Statz and Ungewitter's Gothisches Musterbuch, further in Hartel's Architectural Details of Middle Ages, and Redtenbacher's Beiträge zur Kentnis der Architekturof Middle ages.

Doorways with arch and lintel.

The usual construction of the door leaves in wood prescribes for them a rectangular form or one approaching it, so that covering the doorway closed by leaves , a straight lintel extendin between the jambs appears to be nearest. Fig. 1284.

Variations from this rectangular form of doorway are found in the smaller doorways open to to their round, pointed or segmental arches (Fig. 1285), as well as in those portals of the transition style and of the Early Gothic period, whose doorway openings are covered by a trefoil arch (Fig. 1286). Meanwhile the door leaves follow the outline of the opening just as little as they are usually cut to the form of the corbels supporting the horizontal lintel, but they are rectangular against the internal face of the wall, in a rebate seen at i in Fig. 1284 a or in a blind recess covered by a segmental arch. See plan in Fig. 1285 a and the back elevation of the doorway, Figs. 1285 and 1286 a.

The clear length of the door lintel can be reduced with great advantage by two corbels projecting from the jambs (Fig. 128.). If the lintel is then loaded by a wall, then further is necessary the arrangement of a so-called relieving arch b. Since for the lintel as well as for the rebate of the door is sufficient a moderate depth of about 30 to 40 cm even for important dimensions, but the wall is more in nearly all cases, it would be useless to carry the rectangular opening and also the lintel through the entire thickness of the wall, this is only necessary for the relieving arch. Thus was already formed a motive peculiar to Romanesque works, whereby the round or later the pointed releiving arch was expressed, and the space beneath it with the lintel and the masonry of the same thickness resting on it, or in smaller dimensions it closed by a slab of the required thickness fitted to the arch, the so-called tympanum. Like the lintel the latter rested on the corbels projecting from the door jambs

or on a part of the jamb, or finally on a combination of both arrangements.

Stepped jambs of arches.

The jamb is divided in two parts, the proper door jamb (g in Fig. 1288) that supports the lintel or slab, and the jamb arch (e f in Fig. 1288). The jambs of most Romanesque and many Early Gothic portalr show externally more or less numerous rectangular steps, where is inserted a column in each angle. This column is either as in Fig. 1288 cut in the ashlars of the jamb, or it is made of a separate stone set on end (Fig. 1288 a) and free, the capital and base bonded in the wall. Longer columns with shafts not readily made in one piece, receive at the middle a band fastened in the wall (Fig. 1286). Particularly beautiful is the effect of the little columns, when set farther from the jamb, so that capitals and bases can develop freely as in Figs. 1287 and 1287 a.

The portal arch consists of several courses turned concentrically above each other. Its division may exactly or approximately correspond to that of the jamb, so that the columns in Fig. 1288 continue in the arch as equally or somewhat larger coursed rounds. Even the columns set on end in Fig. 1288 a may be imitated in the arch, where freely projecting rounds a (Fig. 1289) rise from the capitals, which in the transition styli are held by frequent bands b . As in the Fig.,the latter take the usual form of rings or bands, or they consist of separate round disks imitating keystones of the arch, such as also occur on the ribs and have already been mentioned there. Likewise is generally a avoided the hook-shaped form of the keystone resulting from the pointed arch, that in the crown is inserted a bonding member in a vertical position, which the halves of the arch adjoin, of w which the north portal of the cathedral at Riga presents a beautiful example in Fig. 1286 (First half of 13 th century). Here the bond extends through the members and bears a corbel at top, which originally received a fegure.

If the round of the diameter of the column is the smallest member, that can be developed above from the column, on the other hand a curved block can be placed on the correspondingly enlarged capital of the column, which fills the entire square a b c d in Fig. 1288 a. While the stepping of the jambs shows the four angles b, d, f, h, the arch members then show only thr

more strongly projecting angles a, e, g. Within these limits m moves the dimensions of the members of the arch. The rectangular angles may be broken an animated on both jambs of the arch by chamfers or by richer mouldings.

There is a certain relation of the doorway arches with the more richly treated side arches, and liekwise to the jambs of the doorway follow the motive of the pier.

Continuous splay behind the columns of the jamb.

The arrangement thus far explained is common to the Romanesque and Gothic portals, and it makes no difference in the form of arch, since a no less number of Gothic portals are covered by a round arch, like the main portal of Notre Dame at Dijon, the s south portal of the church at Haina and two side portals on S. Elisabeth's church at Marburg. An actual difference therefore exists only in the details, as well as in the more slender proportions of the columns. But as a decidedly Gothic motive is regarded the replacing of the rectangular angles of the jamb between the columns by a continuous splay, but where the arches retain the old stepped form for structural reasons, as we have mentioned in relation to the side arches of Freiberg minster. Fig. 1290 shows the plan of such a jamb with the arches and the capitals of the columns, where the splay adjoins a rectangular reveal a, that can be moulded on the angle. Just as those rectangular angles of the jamb between the columns (Fig. 1288 a) w were usually moulded, so may also the splay be animated by a system of mullions or smaller columns connected by arches, either placed behind or between those in front, and the crowns of whose arches stand below the underside of the capitals of the latter (Figs. 1291, 1291 a). On this rear colonnade the arches may also be omitted, and the solution made on the splay be a horizontal moulding or continuous cove extending from the cavetto from which rise the capitals, or finally be made by a connection of the capitals with each other. We shall see below to what reductions this arrangement leads.

Bonded and free little columns.

The little columns made of entire pieces and set free before the coursed masonry of the jambs, which is the rule in France, is less commonly found in Germany as well as on the piers, and the local position appears to have had no influence thereon. Thus they are found on the Early Gothic south portal of the

church at Haina, while they are avoided on the scarcely later portals of doorways of S. Elisabeth's church at Marburg, only a few hours distant. The same conditions appear on the almost contemporary churches at Volkmarsen and Wolfhagen belonging to the Westphalian architectural group. A diversity of materials did not cause this difference at the places mentioned, nor even the dimensions of the portals, which nearly accord. Meanwhile in the existing cases just from the latter may be derived the determining reason for the choice of one or the other construction, for the arrangement of the free sta ding little columns certainly seems to require certain proportions in dimensions.

If we place little free columns in Fig. 1287 a in connection with those sectangular angles of the jambs with a width of 1 to 1.2 m of the doorway and a height of 2 1/2 to 3 m, the dimensions of the sides a b ara first determined by the usual dimensions of the ashlars, since on the one hand that adoption of the stepped plan is based on the acceptance of the joints b c and b d, on the other the dimension a b is again dependent on the depth of the arch, which again is fixed by the ordinary dimension of the stone, hence as a rule being at least 25 to 30 cm. Accordingly there certainly results for the little jamb columns moderately heavy proportions as shown in Fig. 1287. If one would reduce the dimension a b, then would the joints b c and b d be omitted and two angles must be formed in one ashlar, i.e., in one ashlar must be cut the angle a b a, namely filled to the little columns. But also aside from this, the little columns r require a certain thickness at places exposed to frequent contact in order to be stable, at least 12 to 15 cm. On the contrary would be permitted the cutting of ornamental forms in the mass of the ashlar. In the richer examples of Early Gothic the bonded members are fully developed as little columns. Such an example is presented by the south portal of S. Elisabeth's church at Marburg, where as shown by the plan in Fig. 1290, where in the angles of the jambs are wrought a greater and two smaller ones separated by hollows. There the elevation shows that all 3 little columns begin with their own capital, which however by the great projection of the middle one unite in an abacus forming 3 sides of an octagon, so that by this is obtained the required base for the mouldings of the jamb substantially differing from the section of the arch.and jamb.

Separation of arch and jamb.

That separation of the form of the arch from that of the jamb, which is wanting on simple works, on the other hand is frequently found executed on later portals and with an entire harmony of mouldings and the omission of the capitals thereby caused, that the hollows first from the base of the arch, or if this were stilted, from the underside of the lintel, are filled by the most varied plant ornament.

On the separation of the arch from the jamb was generally laid so much stress, that even with entirely similar members the capital was unwillingly omitted, or its place was occupied by a branch laid on, an animal or a shield of arms as a separation. Even the latest Gothic still menerally separates the arch from the jamb.

Foliage and figure ornamentation on arches and jambs.

Foliage on the arch.

Only simply executed works were satisfied by a mere moulding of the arch layers. If men already in Romanesque and especially in the so-called transition style had sought richer decoration of these arches in the most varied ways, Early Gothic art continued in the same course and ornamented the separate layers of the arch with the most charming forms of foliage, indeed all, or so that decorated alternaded with moulded ones. The arrangement of the foliage is about as follows. A great simply cut cavetto or one with little rounds placed on the flat surface is cut in the angle of the ashlars and covered by foliage. This cavetto either passes above the capital back into the rectangular angle in any manner, or it extends to the capital, yet as a rule so that some bold form, a head, an animal, or a bending of the stem of the foliage is on that intermediate surface and thus forms the transition. The foliage itself is suited to the jointing in its sepaaate parts, and the separate leaves, bunches of leaves or plants stand in a line concentric with the arch as in Fig. 1293, or radially and thus across the hollow, or they are placed obliquely, or finally they form a continuous and still more conventional ornament, on the earlier French examples. Usually are also found here this volute shaped bunch of leaves, and indeed in the same positions and thus either projecting from the hollow or supporting its upper edge from the lower one, generally connected by leaves, about as in Fig. 1294. These volutes sometimes

grow out of the rounds instead of the hollow and even project beyond the face of the arch. It is to be noted, that the sharper separation formed by the volutes, also on the older examples The arrangement of liner forms of foliage is striven for by the movement of the leaves (Fig. 1293). A very rich example of the connection of volutes with leaves is shown by that south portal at Marburg (Fig. 1290). Also generally the foliage at smaller scale is placed in the hollows separating the round at both sides from the flat surfaces, so that two such bands adorned by leaves are formed beside each other.

Figures in the arch.

In the richest style there also occur here figures instead of foliage, and indeed it has been led to one of the most ingenious motives beculiar exclusively to Gothic architecture, namely to that splendid arrangement of seated or standing figures, separate or arranged in pairs or forming groups, covered by canopies and again seated on those, in this alternation occupying t the entire layer of the arch. The figures on the arch represent the blessed in a serial arrangement as a frame of the sacred scenes on the tympanum, on the inner arch being the angels, on the next the church fathers, etc. The entire arch appears like the vault of heaven peopled by saints and the blessed. The sight of the series of arches diminished in perspective is led from step to step nearer the divine, which finds its own place in the tympanum.

The structural execution is about as follows. In Fig. 1295 a let a b be the moulding of the arch layer, then the part of a polygon inscribed in the right angle d c b gives the plan of t the canopy, just as the separate figures are cut in the highest relief from the same mass d c b; Fig. 1295 gives a view of such a piece of the arch. There each figure is made from one ashlar, so that the radial joint goes between its head and the upper canopy, or it is also found under its feet, which then either goes through the clothing or a piece of the base, or finally a low pedestal is united, again being a joint. Thus the crown of the arch is either formed by two canopies growing together, or the last canopy of each half arch remains a little distant from the crown, whereby the keystone between them either remains voi or is adorned by a separate figure like one standing upright, a head or by foliage.

On the later works the endeavor to create those figures in greater relief led to replacing those wrought from the ashlars of the arch by free figures, so that only the canopies are regularly wrought from the arch, but between them the hollow is cut smooth and at its back is fixed an iron hook, and later holds the back of the free figure when placed there.

Not entirely with injustice in modern times has the last mode of fixing been blamed. But in an exaggerated way this blame was also extended to the first entirely structural arrangnment, was based on the position opposed to the laws of gravity, as if the same objection could not be made to all slucpture of the kenstone and further to all covering ornamentation. The soaring position of the figures can here offend the less, since as stated, such usually represent the inhabitants of heaven.

With the construction of the arch of several concentric layers, there results from their unequal length the necessity to increase the number of figures toward the outer layer, so that in the innermost half are 5, in the next 6, in the outside one 7 find the same space.

Figures before the columns of the jambs.

On richer works the jambs as well as the arches are adorned by figures, which by their dimensions usually exceeding life s size are distinguished from the latter, and therefore require a special mode of placing. On the older French works these have their corbels in a way similar to those of the voussoirs, they are wrought from the little columns of the jamb forming monoliths, which easily furnish the required mass for them, since these in the rarest cases can be quarried only in the dimensions required by the diameter of the column. On p. 485 we have already mentioned the same arrengement in regard to the rounds, which is the following. For the shaft of the column (Fig. 1296) which in its round form stands on the bonded base, close above the latter is wrought a corbel, that is described on p. 486, u usually assumes the form of a low canopy, on which stands the figure connected at the back with the column, so that its round form of the column appears above beneath the capital.

According to this earliest and simplest arrangement the figure thus occupies nearly the entire height of the shaft of the column. Over the figure is then required a canopy, which in this equality of height can be arranged in two ways. On the

cathedrals of Paris, Rheims and Chalons the capitals of the columns as shown by Fig. 1298, join a projecting member decorated behind by foliage and cut in the same block, and indeed this joining is either complete, or the capitals project a little b beyond the face a. Thereby they form above the capitals a surface parallel to the rear splay of the jamb a b in Fig. 1299, from which project the canopies, that either in the ground form consist of several abutting or detached polygons as in Fig. 1299, or form a hood parallel to that splan as on the west portal of the cathedral of Rheims. (Fig. 1298). The first arrangement is found in Chalons and on the portal of the north transept at Rheims.

Above the canopy is then placed either directly the arch members or that stilting, so that the original rectangular blocks of the voussoirs, from which the hollows filled by figures are cut, again come to stand over the columns, whereby according to the dimensions of the projection of the capitals a part of the projection of the canopy is either utilized for the base of the figure, or the latter remains behind it. But on certain works there is found no such direct relation of the number of layers of the arch to the jamb columns (Fig. 1299).

The second method of the arrangement of the canopy, that is found on the west portal of Notre Dame at Dijon among others, consists in this, that it is placed one course lower, and thus instead of being one course above the capital, is takin from t the course with the capital. Accordingly the bell of the capital also projects with the little arch of the canopy, and this foliage lies partly beneath according to the general arrangement of the latter (Fig. 1297). The middle of the canopy thus projects before the outer edge of the capital, so that before the arch resting on the latter may still be gade an addition on the canopy.

On the portals of the cathedral of Amiens then disappears this agreement of the heights of the figures and the little columns of the jamb. In the arrangements mentioned, the former stand on a low canopy located above the base, but occupy only a part of the height of the column. above this is then found the canopy likewise connected with the column, which at the same time produces a connection with the jamb, and between the latter and the capital is again a short and free part of the column, so

that directly on the capital again rests the hollow of the arch filled by figures and canopies. On the whole this is the same arrangement, which is mentioned on p 485, and also customary on the vault rounds with figures in the earlier style.

Figures on little columns.

But just as there the proper function of the rounds on later works was thereby changed, so that they are omitted behind the figures, there is found the same arrangement employed on the j jambs of the portal in that way, that the figures stand on short columns, which therefore terminate under them with their capitals, while those upper portions of columns are omitted and the hollows in the arches filled by figures rest directly on the canopies. The entirel arrangement differs froc the preceding in this, that the canopies of figures of the jamb come directly beneath those of the arch and not as in the preceding stand before them. Thus the little jamb columns are entirely omitted a and only like reminiscences of them remain those little short columns supporting the figures, that likewise can be made of detached blocks.

Just as the figures of the arch gain in effect by being placed in hollows, so was next the endeavor to ensure the same advantages to those standing in the jambs, and thus the hollows in the arch under the canopy or impost cap were continued behind the figures to the capitals supporting them, or even to the base, whereby also the canopies of the jamb figures project from the hollows and no longer afford a bearing for the members of the arch. Fig. 1301 shows the plan of such an arrangement.

A very peculiar form of this kind, whereby is preserved at t the same time the picturesque effect of that free standing little column is found on the west portal of Freiberg minster. Here alternates in the arch a layer with a hollow filled by figures with one ornamentally moulded and adorned by foliage in the hollow. Both arrangements are intercepted by little capitals, but otherwise continue in entirely similar fashion down to the base. But in the hollows are 3 little columns c placed in an equilateral triangle in Fig. 1302, whose capitals are taken from the layer of the jamb and end in a common abacus, which rests on a pedestal of the same ground form, whose side surfaces are richly adorned by blind niches and relief figures, and that bear a figure group. Above the latter then begins the usual

filling of the hollow by figures and canopies.

In smaller ones requiring a lesser diameter of the columns disappears the possibility of a free arrangement of the same in entire pieces, and their connection with the coursed masonry of the jamb becomes a necessity, so that the cutting of the hollow down to the base is omitted, and between the latter and the capital receiving the figure a member formed like g h i k in Fig. 1301 takes the place, as on the south portal of S. Maria at Mühlhausen.

Figures on pedestals.

On the west portal of Strasburg minster is then found the arrangement common on richer works from now onward, according to which the supports of the figures abandon the form of the column for those of square or octagonal pedestals to which extend down the hollows filled by figures and canopies in the usual way in jamb and arch, so that thus in the plan of Fig. 1303 a b represents the plan of the pedestal and a d c is that of the h hollow above it. The pedestals then have at last the height of a man and are decorated on their sides by blind arches usually ornamented by reliefs, spanned by arches crowned by tracery gables in the richest manner.

On those earlier jambs with columns there alternates as a rule a column with figure and a plain one, since then the great dimensions of the figure requires such a change. The same alternation is found on the Freiberg minster, p. 544. But allording to the plan of the jamb at Strasburg this separation of the hollows filled by figures is effected only by the mouldings worked on the same ashlars.

Before we go farther there must be mentioned also certain reductions of that earlier system of treatment of the jamb.

Thus on the west portals of the cathedral of Noyon the little columns of the jamb are omitted, and the figures covered by canopies are placed directly before a plain splay cut behind them. On other works then the figures are also omitted, but on the other hand that splay is divided by blind arches, as such an arrangement in connection with the little columns of the jamb was already mentioned on p 540.

Striking jamb and middle pier.

Side jamb for striking.

The internal projection of the jamb forming the strike of the

door and supporting the tympanum of the arch, according to its separate function, is usually to be distinguished from the other members of the jamb supporting the arch. The simplest case is that of a plain rebate with neither base nor cap, from which r rise only the somewhat projecting corbels for the lintel.

On many older works it receives the form of a plain pier, which is surrounded by the capital and base of the jamb, both of which are cut off flush with the leaf of the door (Fig. 1290).

The angle has a chamfer, a cove or even a richer moulding, in which again predominates a round with a capital. By the capital can either the entire member be returned to the square, a and then the lintel may also remain simply square, or the moulding can continue above the capital, break around horizontally and thus accompany the edge of the lintel. (main portal of church of S. Elisabeth at Marburg). It is there preferable that the moulding of this strike of the door be distinguished by greater refinement from that of the jamb.

In every case the corbels are of great service, by which the free length of the lintel in one, the useful width of the opening of the lintel in another is reduced in an entirely unlimiting way, and which can be combined in the most varied ways with each of the forms mentioned, while it may either be connected with those capitals by increasing the projection sidewise as in Fig. 1290, or project from the plain jamb inside the moulding, or finally can be surrounded by that moulding or a part thereof. On richly executed works the fronts of these corbels are decorated by crouching figures.

Middle pier.

But with that unusual width as given by the proportions in g greater works, partly resulting from religious needs, further come a supporting of the middle of the lintel of the doorway a and thus the arrangement of a middle pier, which was constructed either of a single piece or of separate courses. Its forms differ according as it assumes a more independent importance or a repetition of the jamb of the doorway. In the last case which tends more to a treatment with columns, and first departs from the construction in a single block, therefore being possible o only in moderate dimensions, the corbels at both sides must be omitted, if they already exist on the stone jambs. Also sometimes a middle pier built in courses is connected with a freely

projecting column by its capital and base, on which is placed the middle figure rising in the tympanum.

A very peculiar arrangement of the middle figure is found with the omission of the middle pier on the Early Gothic church at Wetzlar. For here the system of the suspended arch is employed on the tympanum, so that the two voussoirs a (Fig. 1300) support the keystone b like a kingpost or struts in wood construction. On the latter are then wrought the abutments against which abut the trefoil armhes c covering the doorway. The figure of the Holy Virgin with the corbel on which it stands is with the suspended keystone are cut in one block. While the spacing by a trefoil arch is also recalled in the transition style, the entire construction is otherwise only a superrefinement peculiar to the Late Gothic.

But in the richer designs of portals with jambs adorned by figures, the middle or principal figure of the entire series is placed before the column b, so that it conceals that for its own height. A connection of it with the middle pier becomes impossible by the great dimensions of the former as well as by the construction in courses. Thus a support for the middle figure becomes necessary, which either can be found by a projecting little column with bonded capital or by increasing the dimensions of the lower portion of the pier. This lower and larger part of the pier thereby becomes a pedestal, whose sides are most r richly decorated by blind arches, indeed frequently in several rows above each other. The canopy belonging to the middle figure is then either bonded with the middle pier, i.e., taken in the uppermost course, or it is already placed in the tympanum, so that the latter rests beside it on the middle pier, then receiving its bearing by corbels increasing the supporting area. Meanwhile also in the first case the finial of the canopy may rise before the tympanum.

The corbels are sometimes replaced by arches turned under the lintel from the middle pier to the jambs, which are usually made very ornamental with cusps, and their spandrels are perforated like tracery. In the latter case they must remain so far from the strike of the door, that they are not struck by the leaf of the door. Also sometimes the lintel is replaced by a segmental arch, or as occurs on certain French works, by a horizontal arch. Usually also and particularly on works in brickwork, the arran-

arrangement of a segmental arch over the entire width beneath the tympanum of the great pointed arch leads to the omission of the middle pier.

Base of the jambs of doorways and portals.

Plain and stepped bases.

Simplest is the form of base for small dooways, whose jambs form the simple continuation of the arch members without capitals or base, and intersect below a projection or a wash. (Fig. 1304). This plain solution occurs little in the Early but much in Late Gothic. The lower part of the jamb thereby becomes a plain splayed surface, that extends in an oblique direction from the external face of the wall to the strike of the door, and its top or lower part is surrounded by the plinth of the building, in case this does not end beside the door.

The portals of the early and middle time mostly had, as we have seen, jambs with little columns, that were completely furnished with capital and base. The base received a little rectangular or polygonal plinth, whereby the jambs had below again a regular stepped form, which rested on the steps or could have separate simplified plinth (see below). On the whole the plinths of the jambs exhibit much similarity to those of piers, as already described on p 214 to 224.

The plinth is then often retained when the capital is omitted and in the late time is formed with such labored and even affected richness in the way illustrated in Figs. 572 to 582, that manifestly forms the greatest decoration of the whole, and therefore came to lie higher, at the height of the eye when possible. A particularly magnificent example of this kind is afforded by the portal of the old university in Erfurt.

Conversely on Early Gothic doors of small dimensions as in Fig. 1290, on which the plinth lies very low, and rounds are sometimes decorated only by capitals.

With the adoption of free columns at the jambs, whether these are placed before a stepped plan or a simple splay, there results for the base of the pier about the form represented in Fig. 558, and everything said of that finds its application here.

The stepped or the compound plan of octagonal bases then generally also stands on a connecting general plinth as lower base, that is broken around the front angle of the jamb and extends obliquely to the inside, finding its termination at the angle

forming the strike.

Under plinth or pedestal.

This under plinth can be formed by the plinth broken around the jamb; if it meets the steps lower or sidewise already before the beginning of the members of the jamb in any such manner is omitted, then in its place can pe inserted a separate and more strongly accented socle, so that a part like a pedestal exists, whose height can then be increased according to the general proportions. This heightening is also produced in a continuous plinth of the building by breaking it around.

Each pedestal may on its own part be also furnished with a projecting cap and plinth and thereby obtain a certain independence, as then on the great French portals it is elevated to an integral part of the entire design, so that thereby the arrangements of the columns and the figures are raised to about the height of a man above the ground, thereby being ensured from any injury and producing a far grander effect.

But aside from the advantages mentioned above, this arrangement results with a certain necessity from the placing of the figures and monolithic columns as well as from the entire dimensio

For those great portal designs, like the windows, fill the entire space between the buttresses, while the plan of the jambs extends beyond the external face of the wall to the buttresses, about as in Fig. 932. Its width, height and depth thus stands in a certain proportion to the entire dimensions, indeed are to be explessed in numbers. On the contrary the size of the separate courses of the arch and of the jamb members depends merely on the dimensions of the materials, but the increased height of the portal must lead to too slender proportions of the columns. Assuming now that men would adopt the latter and could even obtain monoliths of the necessary height, yet they could not secure the same height for the figures connected with the columns, since the widths of the jambs did not suffice for the breadth of such colossi. Bust as it would appar unsuitable to take a smaller height for these figures, because the required mass of the block would be cut away under them, and thereby only for merely an ornamental motive would the fourfold mass of stone have been used on the colunms. It would only have remained to make the shafts of the columns in two pieces, and to connect them with the mass of the jamb by a band, hence making the

subdivision of the columns, which still in the entire proportion was to be elevated in a far more expressive way to be a subordinate division of the jamb.

Thus the socle mentioned is omitted on all these jambs of portals, whose little columns are wrought from the bonded ashlar courses, while men busied themselves in other ways to appoximate their effect, and just here might be sought the real reason of the origin of those richly decorated pedestals, which occur as supports of figures on tehe portals of Strasburg, Cologne, Rouen, etc., and whose relation to the jamb pedestals, from we started, are even more clearly expressed by the rich mode of decorative treatment.

Development of the socle.

The further development of these socles is very varied. On t the Liebfrauen church at Treves and certain French cathedrals the oblique surface between the cap and socle is animated by purely ornamental blind arcades, whose panels are decorated partly by patterns and partly by figure reliefs, and which appear in the same relations to the colonnades above in this relation, with the little columns that receive the arches of these arcades either stand before those of the jamb or before the middle of the intervals. This arrangement then sometimes leads to a reproduction of the stepped plan of the jamb between the lower little columns, whereby the splay is only indicated by the blind arches and the socle of the pedestal. On the contrary on the cathedral of Rheims the side surfaces of these socles are covered by carved drapery, that is also continued around the buttresses separating the three western portals, like the ornamentation of the portal jambs by the decorative columns and figures (Fig.1305).

The most common mode of treatment consists in the adoption of a tapestry pattern wrought in very low relief on the surfaces mentioned, in which the ground of the separate panles is generally again filled with figures in the flat. Sometimes (thus on the cathedral of Amiens and at Noyon), these sides are separated in two divisions, either the lower being smooth and the upper having a pattern, or their patterns differ from each other in size and scheme. Fig. 1306 shows the treatment concerned on the cathedral in Amiens.

We cannot omit here the remark, that these tapestry patterns

that are so common in French architecture and animate the plain surfaces in so many places, form a substantial and very advantageous characteristic of them, that unfortunately has remained foreign to Germany in a way, at least in the sense here indicated, which was almost too liberal with the use of more severe architectural forms on any favorite place. In reality these flat patterns form an easily executed means for obtaining great richness, and the effect of those severer forms are heightened by contrast, and accordingly they certainly deserve to be introduced also among us.

On the portal of the calendar at Rouen are found those patterns in a way very similar to that in Amiens, executed in the blind panels of the separate pedestals of the figures, and just like those of the middle pier.

2. Tympanum of the portal.

The inner and proper opening of the doorway can be covered by an arch, as we have seen above, whether trefoil, flat or straight arch; but the rule forms the lintel or the stone slab closing the entire tympanum, that rests on the inner pier of the jamb or its corbels. It stands abruptly beneath the arch alone, rests behind in a surrounding rebate, or is let into the jamb arches like tracery (Figs. 1148 to 1148 c).

Joints in the tympanum.

When the dimensions allow it, the entire tympanum consists of a single stone (Fig. 1307), otherwise of several courses laid on each other (Fig. 1310). Not rarely are combined the lintel and the slab filling, when the opening is first spanned by a strong beam on which rests the tympanum composed of one or more pieces. On numerous Romanesque and Early Gothic doorways in lower Saxony and on the Rhine, the lintel is enlarged at the middle with a clear understanding of its static problem (Figs. 1308 from churches at Leyden, Billerbeck, etc.). On the church at Sinzig (Fig. 1309, after Redtenbacher) in order to relieve the lintel an open joint has even been left over it, and the tympanum is cut like voussoirs. Larger portals frequently exhibit above the lintel a filling in courses (Fig. 1311). As a splendid example may be taken the principal portal of the church of S. Elisabeth at Marburg. But not rarely are also employed vertical slabs (Fig. 1312), suited to the distribution of the figures as on the cathedral at Wetzlar.

Treatment of the tympanums of simple portals.

Only in very simple examples has the filling remained plain, but as a rule is it ornamented in different ways, and indeed on works in the Romanesque style. The simplest mode of ornamentation forms on the surface wrought crosses, circles or quatrefoil, whose outline is formed by a chamfer or moulding, its ground being either plain or filled by rosettes and foliage, or a symbolical relief like the Lamb of God. Sometimes such rosettes or o other forms in relief project free, where however a like projection accompanies the outer edge of the tympanum concentric with the arch, and either also continues along the lower horizontal line, or stops on the innermost part of the jamb. The lower edge of the slab is simply cut squara or is formed with a projecting moulding. Also sometimes that moulded edge extends over the tympanum in a trefoil arch.

A richer treatment of the tympanum results from a digure representation covering its entire sufface within that enclosure, by scrollwork as in Fig. 1290, by a tapestry pattern or by tracery. The last arrangement may be termed that most unsuited, w when it assumes considerable richness as on certain Late Gothic works and particularly in brickwork (Essenwein, Norddeautsche Ziegelbauten, Adler, etc.), and does not serve to enclose panels separated otherwise or for a window opened in the tympanum. Generally and especially for new works to be executed to economize tracery as much as possible, and to prefer any other mode of d decoration to that, where it does not concern a really structural purpose or even best correspond to the character of tracery.

Treatment of tympanum over double doorways.

More complicated arrangementr arise for those double doorways separated by a middle pier, that are peculiar to the greatest designs of portals. Here we first find the figure above the middle pier already mentioned on p. 546, that either stands on a little column projecting from it ir a corbel and fills the middle of the tympanum. For further filling it are often found two smaller side figures, that are wrought in relief. from the thickness of the tympanum, or are likewise placed free on inserted corbels. The ground behind these figures on the west portal of S. Elisabeth's church is filled by extremely beautiful scrollwork, that consists of vines on the right of the principal figure and of roses on the left.

Another more geometrical treatment consists in this, that bl-ind arches extend from the middle pier to the wall pier forming the strike above the likewise rectangular openings for the doors so that in the panels indeed by them are carved two side figures in relief out of the thickness of the blind arches. Such an arr-angement is found on S. Cyriacus at Duderstadt, (Note), where over the principal figure a canopy is also inserted in the tym-panum, and the ground of the tympanum above the blind arches b beside the middle figure and the canopy as well as under the p portal arch is filled by scrollwork.

Note. Statz und Ungewitter, Gothisches Musterbuch.

On the south portal of the church in Volksmarsen on the cont-rary, these blind arches over the door openings change onto act-ual perforations, so that here is no space for those side figu-res. Therefore free columns are placed before the jambs in the same manner as before the middle pier, which bear the side figu-res, here the princes of the apostles. The latter also come to stand at the same height as the principal figure and are cover-ed by canopies, which at the same time supply starting points for the portal gable, while the canopy of the middle figure of the tympanum is inserted beneath the keystone of the portal arch. On the continuous horixontal line of the position of the figures is based the extremely quiet and clear effect of this arrangement. On the contrary on other portals the columns on which the figures stand are kept lower, so that the middle fig-ure stands higher (Fig. 1300).

The arrangements mentioned are all based on the upward trans-fer of the sculptured ornamentation of the jambs peculiar to t the greater portal designs, to the tympanum and the division of height corresponding thereto, while on the other works, likewi-se of moderate size, as on the south portal at Çolmar, the jambs are only formed by the little columns, and the tympanum receives its own relief ornament. But these different modes of treatment afford substantial proof, how intelligent was the mediaeval ar-chitect of the earlier period, in inventing the system most su-itable for the dimensions, and how far all attempts were from him, that weakened great proportions by the repetition in lit-tle dimensions.

Here not enough can be attributed to later pressure, since t the last endeavor, the carrying out of an unlimited proportion,

still appears on certain portals of the later periods. Therefore we mention here the chapel added to the Frankenberg church in the 15 th century, which with all magnificence and purity in the formation of the details, yet sins in that it reproduces the entire arrangement of the portals of Strasburg and Cologne in small dimensions.

Reliefs in the tympanum.

Comprising all, therefore we might regard life size as the smallest dimensions for the figures on the jambs, and regard them as restricted to such dimensions, which do not require the figures to rise above the height of the springing, and thereby allow a pedestal under it of half the height. In such dimensions also then the decoration of the tympanum again occupies an entirely independent position, and consists of a series of scenes represented in relief, that relate to the holy person to whom the portal is dedicated and the endeavor is severely arranged. As we stated, the size of the tympanum, whose height is still increased by stilting the arch, excludes its formation by one slab, there results from this an arrangement of separate representations in different rows over each other. Hence each slab has a continuous series of figures with one beneath, moulding plain or decorated by leaves, or a series of canopies is carved. The latter serve at the same time as a base for the figures on the same slab, and as a covering for those underneath. It may here be an advantage to carry out the division in height found on the jamb also on the tympanum. Such an example is offered by the side portal of the west facade at Amiens, where the underside of the lower slab at the height of the canopy projecting from the column of the jamb (p. 544), and the top lies in that of the capital, so that its abacus extends on that slab with the same or a harmonizing member, thus characterizing the agreement in height. In the horizontal division cay be caused a greater variation, that in the middle in contrast to the broad one may be employed a high placed slab set on edge with a corresponding relief.

To the representations we shall return later, on the mode of treatment may it only be stated, that the vicinity of the high projecting courses of the arch with their boldly effective figures with canopies in the hollows, also require a strong relief in the sculptures of the tympanum and a crowded position of the

separate figures.

3. External enclosure and crowning of the portal.

Crowning moulding.

According to the simplest arrangement of portals with jambs developed in the thickness of the wall are so placed in the face of the wall that at each side remains a plain part of the wall. As the nearest ornament then results an addition of a concentric projecting hood moulding, which with a simple profile can be ornamented by foliage in the cavetto, and on whose arrangement and solution all necessary has been said on p. 552. The use of this results almost of itself, when the hood moulding instead of passing above the arch joins it, that most simply c can be produced by making it concentric. Instead of this is generally found a rectangular or gabled carrying around of the cornice concerned, the last generally being stilted vertically according to the proportion of height.

Finials and tracery gables.

Meantime these forms of crowning do not require the motive of the cornice, but can also be independent, so that their springings may be corbelled out at the height of the base line of the arch, terminate in a scroll or any other projecting sculpture, run to a head or an animal projecting from the face of the wall. Such a solution results very easily from the arrangement of the portal sculpture in Volksmarsen with canopies over the side figures described on p. 550, where the gable cornice either as there continues in a horizontal direction by a bend, or forms its own line of inclination, so that any proportion of height may be attained thereby. Now so that pinnacles or entire finials may stand in the required position on the canopies, the effect of finials and tracery gables is obtained. Thus also are found in that position simple finials on columns, corbels or priers. At least on the better works the finials and their supports are only made light and purely ornamental, excluding all conception of stbuctural importance not really existing. Special weight might be laid thereon, in view of many later experiments, where the massive buttresses were placed before the portal jambs, but whose projection is nowise utilized for a deeper form of the portal arch, and which therefore have nothing more to do than to stand as guards beside the doorway. If it be allowed to men-

mention the restoration of Cologne cathedral otherwise than a model, we might designate that mighty development of pinnacles between the portal jambs of the transepts and the buttresses separating the latter from their side aisles as examples of designs better avoided, but at the same time another point comes into consideration here, to which we called attention on p.556.

Increasing the depth of jambs of the arch.

Meanwhile such buttresses may have their use, if arches are turned between them flush with their fronts, that accordingly increase the depth of the portal arch and of the covered space before the doorway. Thereby arises a part of the portal projecting from the face of the wall, and that crowning like a gable becomes an actual roof of the projection. This arrangement is then commonly found, among others on certain Westphalian works in a way, that part of the buttress rising above the beginning of the gable assumes the form of a slightly corbelled pinnacle, or in the simplest case is entirely omitted, so that the entire projection must lie beneath the gable. On the treatment of this gable with covering cornice, angle ornaments and crowning applies everything generally said above concerning gables and tracery gables.

There should not be omitted here the portal crowning of the Mariastiegen church at Vienna (beginning of 15 th century), that instead of tracery gables has a pentagonal or hexagonal canopy, that partly lies in the thickness of the wall and is partly free before the external face.

Simple porches.

By increasing the projection of the buttresses is found the means of increasing the depth and importance of the entire enclosure, and thus passed gradually to the development of a porch. By covering the plain surfaces of the piers, which are ornamented by blind arches, little columns placed before them or by figures, or that again can be strengthened by angle buttresses, especially if the arrangement of the vaults permit such, this is capable of every expression from the greatest simplicity to the highest richness.

It further leads to those portal structures peculiar to Italian architecture, which consist of two columns standing before the wall and connected with it by architraves, where a tunnel vault is turned from one architrave to the other. The spreading

of the vault is indeed there prevented by iron ties as generally in the South, and so that opposed to the stress of the arch slender columns are possible. By an enlargement of the columns properly permissible in our style by varied arrangements of coupled columns, by connection with the buttresses at the angles, substituting or supporteng that architrave by arches, introducing the cross vault instead of the tunnel vault, result the most diverse transformations of the motives mentioned as corresponding to the principles of the Gothic style.

Relations of the portal to the buttresses.

By a continuation of the form of the jambs of the portal to the nearest buttresses belonging to the structural system of t the entire work, and the complete filling of the space between the buttresses thereby obtained, results then the just explained arrangement peculiar to the richer and greater works.

According to the proportion of the buttresses to the whole a and to the width of the portal, four cases are here possible.

1. The jamb reaches the front of the buttress in the once commenced stepped or splayed ground form with its columns placed before it. (Fig. 1313).

2. The jamb would not reach them on account of the small projection of the buttresses, and thereby would become necessary an addition to the width of the buttress to the height of the portal gable or an interruption of the form of the jamb by means of a plain part of the wall, about according to the plan given in Fig. 1313 a, whereby the arches of the separate parts m must not exactly be concentric.

3. The sides of the buttresses already extend much earlier from the form of the jambs, thus within the outer corners (Fig. 1313 b), so that the buttresses form a strong projection.

4. In the last case a vault is between the buttresses, as on the transept portal at Chalons (Fig. 932) and the west portals of Amiens (Fig. 1214).

Combination of adjacent portals.

But we must here go more fully into the mode of treatment of the last mentioned works. On both the columns of the portal jambs project at the sides and beyond the fronts of the buttresses (Fig. 1314). Now in Amiens the columns bear on their capitals richly moulded ribs concentric with the portal arches, between which appears the tunnel vault, and that farthest in front

the terminal is beset by a system of little suspended arches, while in Chalons the capitals of the columns are connected by a continuous moulding about as in the manner shown in Fig. 1298, on which the tunnel vault has its bearing, no longer divided by ribs, but only bordered in front by a projecting band resting on the capitals of the columns concerned. But the surface of this in each half is animated by three rows od six cling ribs on each, which must at the top ridge be according to the way shown in Fig. 1315. The portal mentioned above as well as that at Rheims and many others as seen in Fig. 1314 have an extremely rich arrangement, in that the system of columns of the porch continue to the fronts of the buttresses.

Even thereby the united character of the triple portal structure is most decidedly expressed. Thus it forms an independent part of the height corresponding to the height of the side aisles, and to the further develop om the buttresses seems opposed, in contrast to the usual arrangement of German works, according to which the buttresses in entirely independent form extend down to the ground and produce a decided division of the three portals.

To create a greater depth for the entire plan of the portals, the depth of the buttresses can be increased, and accordingly if the oblique direction of the jambs as in Fig. 1313 goes to the angle a of the proper buttresses, these continue in that increased depth of the buttresses as given by dotted lines, so that the width of the buttress diminished. That addition to the depth then passes into massive little towers placed directly above the height of the springings of the portal arches, so that even thereby its entire relation to the portal structure is express

Gable roof over portals.

The projection that the portal arches accordingly form before the upper face of the wall requires a separate covering, attained by gable roofs on older works, so that the cross section through the crown of the portal arch assumes about the form shown in Fig. 1316. With a considerable projection of the portal would however occur a considerable decrease of the dimensions, and t the rectangle a b c d would be made solid.

Detached gable walls.

Accordingly there results the design of a gable wall e f resting only on the foremost arch, whose thickness is only required

by its own condition of stability and behind it being the terrace c d with surface lying at the height of the internal floor of the triforium, and that by means of the passage through the buttress is in connection with the passage at the base of the side aisle roof. But since the width of this terrace according to the projection of the portal structure may exceed the dimension required for access, it is next to cover this surplus width by a separate shed roof adjoining the gable wall and sloping down to the passage described above. This arrangement is found on the cathedral at Rheims, formed about according to Fig.1317, whereby that shed roof c d is placed on a detached pier a, which is connected with the gable wall by a header b and so increases the stability of the latter. In similar works the gable is also then omitted, and the portal structure then terminates with the passage alone.

Removal of water.

Removal of water from the floor of the passage can be effected in different ways. In the simplest case as in Rheims, a spout can be carried through the buttress, ending before its middle. On the contrary in Amiens the perforation of the buttress is avoided, the water spouts being doubled and thus lying at b both sides of the buttress, and are arranged at the base of the gable extending over the portal. Instead of these the passage can also be carried around the offset of the upper part of the buttress, thereby arranging spouts accessible from the sides.

The inclination of the gable is sometimes small on the older works, rising little more than an angle of 45°, and meantime b becomes steeper on later works in the measure, that the portals themselves have lost size and importance.

Treatment of tympanum of gable.

With these small inclinations the gable tympanums themselves are generally left plain, or only ornamented by a circle with cusps or a polyfoil, animated by three little rosettes in its spandrels. The enclosure of these figures, the ends of the cusps etc were usually decorated by foliage.

Richer forms then result by its division into mullions and a system of tracery. In the first lase the panels between the mullions can be again filled by figures, which are related to the meaning of the representations on the tympanum of the arch, so that the principal representation on the gable found in a great

blind niche covered by a canopy forms the conclusion of the entire cycle of figures. Of special beauty is the gable area on the principal portal of Strasburg minster.

In the second case with the resolution of the gable into a s system of tracery, its separate panels may be filled by figures. A particularly good effect is produced if it rises with heads, arms, wings or even the ends of drapery above the bars enclosing the panels of tracery, thus breaking the geometrical scheme. A particularly rich example of this kind is shown by the portal on the north side of the cathedral at Rouen.

Treatment of the wall surfaces beside narrow portals.

We have already mentioned above the different arrangements, by which where the conditions do not permit a principal window filling the entire width between the buttresses, the effect corresponding to this arrangement will at least be striven for. T The same case may also occur for portals of available height t that reacts on the width, and lead to the most varied solutions. The entirel width may be divided in two parts, so that the treatment of the elevation comes to that of two portals beside each other. This is found on the west front of the cathedral of Laon.

Another more ornamental arrangement consists in this, that t the space between the buttresses and the portal is filled by b blind tracery, that is either arranged according to the mode of the inner arcades, thus only going to about the height of the lintel of the doorway, or it occupies the entire surface up to the next horizontal division, and thus also continues above the gable of the portal as on Strasburg minster. Here this blind tracery becomes free standing high arches lying before the face of the wall, that bears the floor of the passage found beneath the wheel window, while the tracery gable of the portal lies on but two slender mullions of this arcade, extended in piers resolved into rich forms of finials.

We must contrast the Strasburg arrangement again with that of the Cologne transept portals, where the space concerned is fully occupied by this massive development of the pinnacles, so that where in Strasburg resulted a lightening and economy of mass by the arcades, here was produced a considerable increase in mass.

Further there belongs here also that arrangement, whereby the architecture of the portal continues in blind tracery of the b buttresses, so that portal and blind work have equal heights,

that are bordered by the hood moulding above them.

Thus the south side portal of Freiberg minster exhibits the arrangement of three arches occupying the entire width, supported by columns and crowned by tracery gables, of which the middle one forms the proper with a further extension of little jamb columns and arches, while thus at both sides are separated in two divisions by little secondary columns and arches. Above is then found the window of the side aisle.

Windows over the portals.

If the doorways first only open the wall beneath the window story, the upper part of a great portal structure may entirely or partly close the window, as shown by the example of Chalons (Fig. 932). With smaller dimensions of the whole these parts may even rise into the triforium or farther into the clearstory and then also may restrict the design of the latter windows. The same case occurs for portals found in the side aisles, or also in transept portals found in churches with aisles of equal heights. In such cases is generally found over each portal a simplified arrangement of the window, thus on the north transept of Gelnhausen, with all three round windows placed in an equilateral triangle, or as on the south window of S. Blasien in Mühlhausen, with a single great wheel window or even a small round window, as on the south side aisle of the church at Frankenberg, or with one of less breadth and pointed above the portal gable. Finally often with greater extension of the height of the portal, the window above it entirely disappears as on the south side aisle of the church in Volksmarsen.

But the converse arrangement also occurs, that the window crowds the portal, at least in regard to the treatment, so that the latter only forms a subordinate division of the former. In this case the window jambs extend to the ground or down to a plinth near it, and the window sill at the same time becomes the lintel of the doorway, as on S. Boniface's church at Fritzlar. Yet sometimes the doorway under the window sill is still spanned by a pointed arch, as on the north portal of the church at Wolfhagen, or finally over the latter is omitted the window sill, so that the window mullions rest directly on the pointed arch as on S. Jacobi at Mühlhausen.

A similar arrangement is sometimes found in this way, that above the lintel of the doorway is placed a window of less heig

somewhat like a transom, the entire part then being filled by piers resolved into finials, and bordered above by a tracery gable, over which is still the proper larger church window, that finds its place as on the church at Haina. Meanwhile all these forms belong first to the 14 th century and sometimes produce no good effect by too great slenderness of proportions.

4. Porches.

Smaller porches and doorways.

A distinction must be made between little porches directly adjoining the portal, that besides their architectural problem have only the practical one of affording to a few men shelter from the weather, and these porticos or rooms like halls, that afford space for a great assemblage and can even increase to church vestibules.

Porches between buttresses.

To the former already lead the extensions of the jambs of the doorway already mentioned on p. 553, that extend as short tunnel vaults between the buttresses. These still appear as directly parts of the portal, and thus appears a separation when the doorway is narrow and still over the entire space from one buttress to the other is turned a tunnel or rectangular cross vault, which is terminated in front by a cross arch set back from the front of the buttresses with the gable or hip roof found above it.

Greater depth of these porches may be obtained by increasing the depths of the buttresses, that may also be made wider according to the span of the porch. Arrangements of this kind are found not only between buttresses, but also in the angles between the choir and the projection of the side aisles or transepts, just as in the angle between side aisle and western facade, etc.

Porches with free middle or corner piers.

The strongly oblong ground form of such porches may by one or more intermediate piers be connected by arches into separate bays approximating a square.

Greater depth with less width can be obtained by detached corner piers instead of projecting buttresses. A very beautiful p porch of this kind is found before the north transept of the cathedral of Magdeburg, which is covered by two interesting gable roofs over the cross vault, and opens in front by two doorways spanned horizontally, where then the tympanum of the side

arch over each double doorway is opened by a wheel window, and slender finials extend above the vertices of the gables from the angle buttresses.

Triangular porches.

A peculiar porch is forded by the portal structure on the north transept of the Erfurt collegiate church which is plan is arranged as an equilateral triangle, that even takes as a base t the width of this transept, while the other two sides are opened by rich and great portals entirely in the system prevailing in the 14 th century for such designs. The present structure w with its second story, is definitely recognized, originated by a departure from the original plan.

An open triangular porch is further found before the principal portal of the cathedral of Regensburg.

Larger independent porticos.

Origin of porticos.

The custom of building larger porticos before the principal entrances of churches extends back into the earliest times of Christianity. To receive penitents and converts was required a vestibule of moderate extent, the narthex, that was often placed in connection with the paradise, a forecourt planted with trees, and this was surrounded by colonnades and generally had a fountain in the middle. The forecourt gradually disappeared, but the portico remained till the 12 th century and generally was before the west facade, extendind for its entire breadth; after the 13 th century it was less common before the west portal, but generally porticos for these were erected before the side doors of the transepts and of the nave. (Cathedralsat Lübeck, Kammin and Riga).

The porticos were covered by vaults or wooden ceilings, the smaller ones were mostly open, but the larger and especially t the earlier ones were closed at the sides, and these sometimes became important three aisled churches (Vezelay), that even in Romanesque times already occurred in two stories (Tournus). S Such great prechurches seem to have been less built in Germany, but on the contrary it is remarkable, that still two forecourts surrounded by columns have been preserved at Essen and at Laach.

One story porticos.

A very beautiful example of the closed portico is presented by the west portico of the collegiate church at Fritzlar, dating

from the early 13 th century, which in the interior bears not a strong Romanesque stamp on the vaults and piers, but on the exterior frequently exhibits in windows and doorways the forms of Early Gothic, indeed in charming treatment.

Open porticos occur on French works, partly in very rich development. Thus such a one is found belonging to the beginning of the 14 th century, before the west facade of the cathedral of Noyon and extending its full width, its three bays corresponding to the middle and side aisles and the width of the towers.

The picturesque effect of this arrangement is substantially enhanced, because the thrust of the vault on the front piers is not opposed by directly strengthening them, but by detached buttresses set a little back, connected with the former by flying buttresses. The entire portico is covered by a terrace, so that a tracery balustrade forms its upper termination.

Two story porticos.

According to the special requirements, the arrangement of a second story above the terrace may be preferable, and the space thus obtained in it may serve for either to receive the organ or the arrangement of a separate hall, or finally for a loggia opening into the church.

An arrangement of this kind is found in the Frauen church at Nuremberg, where to the rectangular portico is added a polygonal structure, that has approximately the same height as the church, so that its roof intersects the gable of the church.

But far greater importance is claimed for the portico building of Notre Dame in Dijon, which like that at Noyon extends in three aisles over the entire west facade, and by its two upper arcades separated by a high frieze entirely conceals that. Viollet-le-Duc states that these upper stories were to serve as connecting two towers before the side aisles but never built and not in the original design, by which certainly the west side would have had an effect differing from the present one, corresponding more to a secular building. Yet aside from that must one lament the omission of one of the noblest works of art exactly corresponding to the construction of the whole on the church mentioned, yet of charming beauty.

At S. Benigne in Dijon is found a portico in modest dimensions, that is made a little wider than the middle aisle, and whose superstructure opens by a low arcade on the exterior.

Porticos beneath the towers.

The numerous open or closed vestibules placed under a tower or between two western towers indeed do not bear the character of separate structures, but by their use are also to be counted with porticos.

The arrangement of porticos certainly at present is not a direct need. Yet their introduction, and particularly if enclosed, would dispense with those ugly wind porches encroaching on the interior, that in recent times have been added ho most old churches. Further that also these are capable of correct treatment in style are nowise held to the opposed form now common is proved by many Renaissance works. A far more worthy development c could have been reached in the Gothic style, whose superiority especially in the development of wood construction would consciously or unconsciously be admitted by great many of its present opponents.

Meanwhile also those open porticos, and especially for such churches to which are added outside societies, dispense with the use of the tavern at least before the beginning of divine service, and that they enrich the effect of the whole by a picturesque tendency. It is self-evident, that in cases of the last kind, vaulting in stone is not a necessity, but that wood construction may rather appear here with advantage.

5. Sculptured ornamentation of portals.

In the development of the different parts of the portal, we have also described the arrangement of the sculptured ornamentation, and it still remains to briefly indicate also the objects for representation according to the principles of Christian iconography.

It is first of all to be emphasized, that the sculptures of the portal form a connected whole, and as such it must stand in direct relation to the Lord, the Holy Virgin or the Saint to whom the portal is dedicated. This unity of the sculptured representations continued on all mediaevla portals from the simplest to the richest arrangement and generally extends to the entire facade.

Simple portals.

In the simplest cases in which sculptures are found only on the tympanum, these exhibit Christ surrounded by the symbols of the evangelists, or Christ as the judge of the world with the

intereessors Maria and John. If the portal relates to the Holy Virgin, then is found here Maria in clory with praying angels, or Maria accedted as queen of the apostles according to the litany, who are then represented by the apostolic princes Peter and Paul. A frequently recurring representation is also the coronation of Maria by Christ.

If the portal is dedicated to one of the saints, then it is a scene from his life, indeed as a rule it is the most popular one that is represented, thus for S. George is the fight with the dragon, for S. Martin the dividing of his cloak, etc.

Portals of great cathedrals.

Far more complex is the arrangement of the figures on the portals of the great cathedrals.

Here the titular figure stands at the middle pier, thus on all portals dedicated to Christ is the triumphing Saviour himself or the Mother of God. On the columns of the jamb or even in the jamb stand the ancestors of the Lord, David, Solomon, etc., and further those prophets that intimated hhe redemption, or in general Old Testament figures presignifying the Sacrifice, like A Abraham, Melchisedec,etc.

Commonly are further found the wise and foolish virgins or t the cardinal virtues, and as end figures of the entire series the Church and the Synagogue, or Adam and Eve as the middle ones.

The representations on the tympanum then comprise the story of the Lord with the Passion in greater or smaller extent also terminating with the Crucifixion, the Ascent to Heaven, or the Last Judgment. On the portal of the north side of the cathedral of Rouen are found the meaning and the origin of the apostolic confession of faith and also in this the Passion. Sometimes the f final representation is placed in the field of the gable or even higher on the facade. Thus on the portal gable at Strasburg two large spaces are found aboev each other, the lower containing Solomon enthroned and the upper the Queen of Heaven, while in the arcade found in the upper half of the wheel window are the apostles with Maria as their queen, and in a vesica rising therefrom is represented the enthroned Saviour. On the tracery gable crowning those arcades stand the choir of angels. Also further the story between the towers opened by two arched openings crowned by tracery gables also serves for the further development of the sculptured decorations in the following way. On the order

of piers turned toward the towers are represented on each two evangelist above each other in human form with heads of the symbolical animals. On the same piers above the junctions of the tracery gables stand angels with the implements of the Passion, in the middle between the tracery gables sits Christ as Judge of the world, and in the spaces enclosed by the gables are the intercessors Maria and John. But there the spandrels of the gables rise as foliage the tombs with figures of the resurrected, and at both sides of the crowning gables, also four in number, stand the angels of the Judgment with the Oliphant.

Also sometimes the Last Judgment forms the sole ornament of the sculptures of the tympanum as on the south portal at Colmar. For here within the pointed arch forming the principal shape of the tympanum is cut a round arch of equal span in the surface. (See Gothisches Musterbuch). In the middle of the latter stands a bishop, who rejects those coming from the right, while he receives those approaching from the left. In the space remaining between the round and pointed arches is separated a middle area in which Christ is enthroned as Judge of the world, surrounded by the angels of the Passion and the Judgment. In the spandrel at the right of the Lord is then found the ascent of the blessed into heaven, while that on the left is again divided in two spaces, and that nearest the middle has the resurrection from the grave, and the lower one contains the punishment in hell; the last is represented by the mouth of a colossal beast, in which is placed the damned.

The sculptors in the courses of the portal arch as a rule place the choir of nine angels, the apostles, the evangelists, saints, prophets, fathers of the Church, virtues and vices, or t the tree of Jesse, in brief the representations of the heavenly hierarchy.

Conversely the various panels of the plinth are rather devoted to worldly impulses and earthly conditions. Accordingly they contain either in the arcades or on the plinth the series of animals, seasons of the year, arts and sciences, representations of agriculture and hunting, sometimes even merry scenes (Fig.1306).

6. Portals of brick.

Use of cut stone.

In the 12 th and 13 th centuries, when brick construction rapidly extended in the German low-lying plains and in the Slavonic

provinces influenced by them, men remained in a certain degree still under the traditions of cut stone construction; where this occurred, the richer parts of the building and especially the portals were entirely in cut stone; an exception is found in the limestone portal given in Fig. 1286 for the cathedral executed in brick at Riga in the beginning of the 13 th century.

Men proceed one step farther, when as on the beautiful Romanesque portal at Seehausen the stepped treatment of jambs and arches is in moulded bricks, while the inserted columns with capitals and bases as well as the rounds extending in the arches from the columns are executed in cut stone.

The arrangement of such stone jamb columns, that can be placed either before an oblique surface or in masonry steps of the jambs, is also in place where the arch entirely consists of brick, and it is particularly effective by the contrast of colors. The small size of the brick courses causes, that where possible two courses of bricks stand on a column, either according to Fig. 1318 or Fig. 1319 (see next page).

Finally such portals are also not rare, on which only the bases and capitals with the impost moulding are of natural stone, but the jambs and arches are entirely built of brick. All cut stone bonded with the brick masonry is to be wrought with a rectangular projection of the greatest required dimensions, that enters the wall so that the courses of brick always stop against vertical end joints and nowhere against mouldings; from this may result an ornamental motive at certain points as shown by Fig.1320).

Portals entirely of brick.

Portals without the aid of cut stone also appear already in the earliest time of brick architecture, and predominate in the middle and later times. It is interesting to examine how at first brick architecture was under the ban of the cut stone forms, but very soon freed itself from these so far, as the particular qualities of the material indicated.

Members of jambs and arches.

On the earliest jambs of doorways it still occurred that the little columns were placed without bonding in the angles of the steps (Fig. 1321), they were made of round clay cylinders, and on the church at Arendsee in the Mark. For slender columns of small diameters, these could not retain the technics of cut stone standing on end, and men bonded the moulded bricks of the c

columns, as by the same portal at Arondsee besides the larger free are also shown such slender banded shafts of columns. For bonding were soon formed dovetail projections on the cylinder on alternate sides and entered the depths of the jamb courses (Figs. 1322 and 1322 a). In the arch the rounds turned in the same direction. (Fig. 1322 a). The diameter of such little columns or rounds mostly amounts to a half brick or 14 to 15 cm, yet there often occur smaller sizes of 1/3 brick or 9 to 11 cm.

The projecting angles of the stepped jambs at the beginning were formed as for cut stone, but soon the convenient technics of moulded bricks and the dull effect of the clay soon led to arranging boldly curved mouldings beside each other, that finally in the later time received such deep recesses, that they could not be wrought usually in cut stone, while they were easily possible in bricks with suitable joints. By increasing the animated sequence of mouldings the simple round little columns receded or entirely vanished (Figs. 1323 to 1324 a and also previous Figs. 958, 959).

Treatment of smaller portals.

At the same time the capitals and bases lost importance and one impost moulding remained only on rich portals till the later time, and the smaller doorways already quite easily assumed a definitely simplified expression. They almost always received as base a plain granite sill on whose upper surface the moulded bricks started abruptly and continued in the arlh without any further separation. The entire portal was enclosed by two or three moulded bricks or even but one if necessary, and thereby presented a play of mouldings, only to be obtained in stone by costly stonecutting. Thus the brick portals exhibit an ever increased adaption to the nature of the building material.

Treatment of the principal portals.

Yet the principal portals did not restrict themselves to such a simple development, but received richer alternating moulded bricks and even great moulded blocks in clay; even foliage and figures with canopies were sometimes modeled as on the castle church at Marienberg. But in general strongly projecting reliefs were forbidden, for they might assume the appearance of affected art. In their places appeared twisted rounds (Fig. 954 a), terra cotta plaques in flat relief, flat patterns composed of moulded bricks and especially treatment in many colors, among which

glazing occupied the most monumental and prominent place beside the white plastered or painted surfaces.

The glazing of the bricks of the arches and jambs was recommended for its durability, but with this the members built of u unglazed bricks easily had the effect of a certain loamy softness, that was heightened by glazing. On north German brick buildings as a rule the glazing is black, brown, green or yellow.

Tympanum.

The tympanum can also be executed in brickwork with particular richness, ornamental and even figure reliefs are there produced by inserted plaques of terra cotta, that are improved by glazing or painting. Instead of these the representation of the objects by simple surface painting produced a rich and grand effect, a and it was employed by preference, for the locations protected by the depth of the jambs. Meanwhile there was here first of all strongly contentionalized treatment with bold and broad outlines in light colors without much shade tint, since a modern soft manner in connection with the simple and sharply distinct lines of the architecture would have injured their effect too much.

Enclosure of the portal.

For the gable area over the portal is suitable the arrangement of separate panels of circular or quatrefoil shape enclosed by masonry, whose ground can be plastered or filled by plaques of terra cotta, or the entire surface may be divided into vertical blind arches, that can be filled by detached stone figures on corbels or pedestals.

When already in certain later works of brick architecture the execution of tracery gables with the accessories, crockets, etc., is attempted, it is in the nature of the case that such works with exaggerated richness can be made partially possible by means of certain not strictly structural means of fastening, partly only such small dimensions occur, that these must seem puerile in contrast with the usual proportions of a portal. Therefore in case the circumstances do not permit the tracery gable and usually all the more richly ornamented parts to be made of stone, it is better to construct a simple portal gable, whose border according to brick construction consists of a projecting round course; even more natural is it to form a stepped gable. Instead of the gable very frequently occurs an enclosure of the

portal by a moulding broken around in rectangular form (for example the hood moulding), with the filling of the enclosed area by a perforated network of moulded bricks with plastered ground.

7. Door leaves and their fixtures.

Nailed doors.

Nailed doors are preferable in contrast to framed, which came into use on church buildings, since generally in their position in the open air certain advantages over the latter are peculiar to them.

The leaf of the door consists externally of planks abutting against each other or joined by tongues, which are nailed on an internal frame most simply composed of two or more cross pieces and an inclined brace, or of a second layer of planks with joints crossing the former. The nails must be well forged with projecting heads, merely flattened, shaped like the segment of a sphere, or more richly ornamented, and well clinched or riveted on the inside. To prevent the sinking of the nail heads into t the wood in driving, these iron washers are placed under them, that afford another ornamental motive. Nails also may be replaced by bolts, but less well by the so-called lag screws. Although connection by screws was very well known in the middle ages, it was not common for this purpose.

Hooks and bands.

In any case the leaf of the door has a smooth surface outside, and the arrangement and execution of the fixtures determine its ornamental character.

In the simplest way the bands are fastened on the outside of the door, indeed just at those internal cross pieces with two bolts and various nails and coiled at the edge of the leaf of the door (thus in Fig. 1325) and these eyes hang on the kooks that are let into a stone and cast, or fixed immovably in a carefully cut groove in a stone. In the latter mode they are also built in between bricks. Such built-in hooks in the simplest c case have the form in Fig. 1325 a, and they clasp at the plain end behind an ashlar or brick, their length for moderately heavy doors amounting to 30 cm or the length of a brick. Stronger are the split hooks, Fig. 1325 b. The example given from the c cathedral at Riga has at the front end an enlargement like a dowel, that strengthens the projecting end and makes it immovab

But as a rule the iron bands are placed on the inside of the

door, indeed on those cross pieces (right half of Fig. 1325), while the so-called ornamental bands are nailed on the outside. The hanging bands are first nailed on the cross pieces and the nails are riveted, the ornamental bands are laid thereon ... connected with the hanging bands by some bolts, that pass through the entire thickness of the door including the cross pieces, and the nuts on them lie on the inside; afterwards the ornamental bands are further fastened by nails, that are naturally shorter and are not riveted.

In spite of their name the ornamental bands have less a decorative purpose than rather the important function, in common w with the iron bands with shorter nails (Fig. 1232), and holding the planks more firmly and ensuring the door against violent d destruction by the splitting of the planks.

Both the hanging and the ornamental bands consist of iron flats, that extend over nearly the entire width of the leaf of t the door, are forged thinner at the ends, are split at the ends in the simplest cases, and both parts are curved (Fig. 1326). By division into three parts results at the end the form of the heraldic lily, (Fig. 1327 .). By more divisions are produced t the most varied leaf or rosette forms, into which we cannot go farther here. In the same way by splitting certain parts at the side and bending those parts, by forging the ends thinner and hammering out the sharper edge lines are animated the straight outlines of the bar. Fig. 1327 shows different modes of executing this kind, and at the same time makes clear the method of working, for each of the little branches a is taken from the m mass of the bar as seen at b. Treatment of this kind, which is proper only for a small width of bar is especially required for the hanging placed on the inner cross piece, while the ornamental bands spreading over a great surface admit of freer forms. This can be formed by reducing the number of splits whereby their length naturally increases, and where the separate bars, if the size permits, can be treated like Fig. 1327 or be further divided. Other forms result by division of the band from the beginning into two or more bars, which either branch from the entire band, or at their junction can be welded together. Figs. 1328 and then 1329 to 1331 exhibit several other forms of this kind. A further ornamentation may the separate parts receive by lines cut while cold, by which the finest engraving can be rep-

represented, and further by chasing the separate leaves and raising a flat modeling by hammering.

Real masterpieces of this ornamentation are the bands of the leaves of the doors of the northwest portal of the cathedral of Paris, that in the wealth of invention and sharpness of execution emulates the most beautiful work created in a pliant material.

If at least two hangers are required for each leaf of the door, then for a considerable height of it yet a third and even a fourth may be added. The ornamental bands as a rule take their principal character from the horizontal direction of the hinge bars, meantime these are sometimes formed also as a scrollwork moving outward from a central point, freer and more like a rosette. Excellent is the effect of the bands placed on the middle of the leaf, which have the purpose of further strengthening the door.

From what has been said follows, that the indicated mode of treatment proceeded from the work of the smith, and that an imitation of these forms in cast iron would be nonsense. If the latter material were generally suitable for hinges and ornamental bands, which is not the case on account of its fragility, then in every case an entirely different treatment of the form would be required. Likewise must the cutting of the ornamental bands from sheet tin, as sometimes attempted in recent times, must be termed a substitute entirely lacking the desired effect, since the reduction of thickness at the ends cannot be executed in sheet metal, whose nature consists in the uniform thickness, and therefore demands an entirely different treatment. The covering of the edges as well as the entire or partial covering of the door with sheet metal naturally can be regarded as a justifiable strengthening.

But it also does not suffice for the wrought iron band, as it must be with the exception of what is mentioned above, is laid out while cold and prepared in the fire under the hammer, and the file must be entirely excluded, even with the danger that the drawing is not very sharply reproduced, which is unavoidable with the slight preparation in art at this day. We know from experience how hard it is to omit the easy assistance of filing, thereby rejecting the smoothness of the surface so much favored and the elegance of the edges formed. Meantime aside from all further use then appears the painting of the iron work as a right of necessity, since every mark of the file becomes a spot

of rust. But then if the manual skill at command makes the file and painting a necessity, then first of all is now to be avoided the favorite blue color, which blue imitates mouldy iron without result, and thereby produces an ugly effect; black or brown ochre is better.

Door lock.

The lock is to be set on the inside of the door, and if the working of the bolt is to be accurate, the case is to be made of one piece if possible, thus showing the form given in cross section in Fig. 1333 with slopind sides and flat adjacent margins, oh at least the fronts of the surface must be covered by a piece c riveted on in Fig.,1333 a.The arrangement of a latch lock is unnecessary and the ordinary so-called German lock with a thumb piece beneath corresponds to the purpose in a more perfect manner.

As to the hinge band corresponds the ornamental band, so there corresponds to the inside case of the lock the lock plate set on the outside of the door, which also covers the rivets of the nails for fastening the case of the lock, or it serwes as a base for schews passing through the thickness of the door and the case As a rule this plate has the form of a rectangle with slightly curved edges and the lower end is extended below (Fig. 1334). Through it is cut the keyhole, that is bordered by an applied scroll of thin iron (b in Fig. 1334). The latter also fills the essential purpose of guiding the key to the keyhole at night.

In the earliest time not all doors were furnished with locks, but they were in part fastened inside by bars or logs. Such a beam 20 cm thick is still well preserved and rests in its place in the wall behind the door of the church at Wolmar in Livland, dating from the beginning of the 13 th century.

Ring and fastening.

To the fixture mentioned is added also the ring for pulling the door, fixed at the middle of the leaf and at a height of a about 1 to 1.2 m. On folding doors without a middle post this naturally comes only on the leaf on which is placed the lock.

The ring turns in an eye a as shown in Figs. 1335, 1335 a, which passes through the door and is clinched inside. Under it is placed a plate b, cut out in the form of a rosette, and sometimes perforated, where certain parts are wrought and nailed on the outside of the door. Sometimes two plates are placed on each

other, and thus more complex perforations are made possible. In richer execution is found here a bronze lion's head that holds the ring between its teeth within a circular frame nailed to the door. The ring sometimes takes the form given in Fig. 1336 and then turns in the eye on a pin. Chiefly on inner doors, it is further usually replaced by a handle, either like Fig. 1337. made ofa single piece of iron with ends forged wider and nailed on, or like Fig. 1338 is made of two horizontal pieces a passing through the thickness of the door and riveted inside, under which are placed the plates b, with a vertical handle c tenoned into the former, that is round or turned; it can be made of a different material like wood.

To the fixtures mentioned then are added the bolts entering the door sill on the permanently fastened leaf.

Further the edge of the ring is sometimes protected by a metal strip laid on it and cut out of a leaf pattern, which supplies a very effective ornamental motive.

Rebate strike.

For double doors without a middle post the leaves strike a rebate very simply arranged on the doors (Fig. 1339), a strike b batton is required for more perfect closing, that is fastened on the leaf first opened on which is placed the lock, and fastened by iron nails with visible heads. This mode of fastening so far prescribes its form, that it must have a surface suitable for driving the nails.

It is accordingly next either to only bevel or cove the edge, or after locating the nails to determine the entire form about as in Fig. 1340, or finally to ornament the front surface by flat carved scrollwork, which is then to be so arranged that t the nails may pass through it in a proper way. On the inside of the leaf of the door the case of the lock presents the arrangement of a continuous batton. Therefore it must either be omitted, or be divided in two parts by the lock, but the case of the latter is furnished with an iron band a in Fig. 1335 b corresponding to the batton, by which the joint produced between it and the strike on the other leaf is closed. This band may further be strengthened by projecting edges and perforated in various ways to form a rich decoration.

Doors with framework.

Instead of the before mentioned composition of the inner door

frame of pieces, this may consist of a regular framework, in t this manner giving opportunity for richer forms, both in the t treatment of the frame, the grooving of its edge, etc., as also that the panels contained in the framework may be richly ornamented or perforated panels of wood or a nobler material be arranged, as on S. Maria im Capitol in Cologne, whose edeges extend under the frame and are held thereby. This mode of execution f forms the transition to the paneled doors.

If we have hitherto assumed the plane side of the door to be turned outside, there is still found sometimes the converse arrangement, so that the framework forms the external side. Likewise in this case the hinges can lie outside and be set on the horizontal rails; still the different branches of the hinge plate must not have a shape exceeding the breadth of the frame, and corner bands like Fig. 1341 may be employed with advantage.

For those important widths of leaves, such as result from the dimensions of larger works, it is advantageous for easy access to allow only a part of a leaf to open for ordinary use. For t this purpose either the ornamental band or the hinge will be divided by a hinge joint, according as the little door is to open inward or outward.

Richer treatment of doors by painting and overlays.

For a richer treatment of internal doors it is self-evident that painting may pe very effective. Here is applicable with great advantage that mode of treatment peculiar to the late middle ages, where a simple foliage or tracery band extending around on a black ground is so painted, that the proper ornament retains the color of the wood. Thus on the smooth surface of the leaf of the door is shown by Fig. 1331, or with a regular subdivision of the framework, on its parts not covered by the hinges, or finally on the panels in the frame were placed geometrical or foliage patterns.

A greater area is obtained for painting by the use of double doors presenting a smooth surface inside, where either the wood itself serves as the ground or this was first formed of a coating. Thus the leaves of the doors of S. Elisabeth at Marburg were covered in the inside by parchment, on which were fastened the hinges and other fixtures, and on each panel enclosed by the bands was painted the imperial eagle.

By the use of such a covering it is advantageous to protect

the angles be overlaid and perforated strips of plate like the covers of books, and especially if the bands have openings, and under them is overlaid a fabric of different color, a further fecoration is produced. Moreover by such overlays man pe obtained great magnificence also in secular buildings, that rises far above the existing luxury, that as a rule stops with wood staining.

For this the doors from upper Tübingen given in Heideloff (Note) afford evidence, which are covered by red velvet and overlaid by bands of gilded copper, beneath which is again placed green velvet visible through the openings.

Note. Mittelalterliche Ornament. Heft 7, plate 6.

IX. DEVELOPMENT OF ELEVATIONS OF TOWERS.

1. Treatment of Towers from Early Christian to the Gothic period.

Purpose of towers.

Towers occur as parts of churches since the 6 th and 7 th centuries numerously in both eastern and western countries. They were little added stair or watch towers, the latter usually isolated before the church. About the same time also extended the use of bells, that were hung on open frames beside the church or at proper places on or above it. If towers existed t that were suited to receive the bells, nothing was more natural than to place these in them. Where this was permissible, men adopted beforehand the form and width of the tower to this purpose, and sometimes also the building between two small stair towers was carried sufficiently high to afford a belfry at top. Gradually the safety of the bells increasing in number and weight evermore determined the erection of one or more principal towers. Besides simpler stair towers also retained their value, that w with the bell towers that together with the bell towers became the most prominent external characteristics of the House of God.

Detached towers. Added towers.

In Italy the bell towers usually remained separate from the church, while in northern lands they were organically connected with it. Aside from the earliest wooden churches not remaining, only in certain countries (Bohemia, Silesia, East Friesland), did the use ofa detached tower receive any consideration in the middle ages. The more difficult but laudable problem was placed before the architect by the combination of the design of the t towers with the House of God. According to this tendency,Romanesque and gothic art busied its endless creative powers again in astonishing abundance and diversity; one may well decide, t that no possibility of the solution of the tower has remained without trial. Especially arose a competition between the eastern and western parts of the church, and this was not alone in the plan with double choir, but also with the plan developed expressly toward the east.

Towers of the eastern half.

At the east the crossing was emphasized by a structure flanked by two or four slender towers, which in combination with the t transverse aisle and the rich choir endings furnished a wonder-

wonderful perspective effect. At the other end rose the western structure according to its importance, accenting the entrance to the church, inviting admission by the call of the bells. Accordingly as the western facade or the crossing became predominant, or both remained in a certain equality, there became the greatest variety by the aid of the varied development of the different towers.

The tower over the crossing could rise square fhom the roofs in 2, 3 or more stories to an important height above the building, as on Great S. Martin at Cologne, S. George at Bocnerville, S. Philibert at Tournus, the churches at Tours, Cluny, and on many English works, or it might be executed as an octagon, whether above the roof as at Königslutter, or already beneath the surface of the roof as on the Romanesque churches of the Rhine provinces, whose lofty crossing vaults also passed into the octagon in the interior. The cathedral at Toro in Spain has a two story sixteen-sided crossing tower with four attached side towers. Such with angle or stair towers starting from the middle structure also occur in other examples in the number of 1, 2 or 4, and on Great S. Martin at Cologne there still rise two stories of the crossing tower above the main cornice.

Far more common than the directly attached little towers are the bolder side towers standing beside the crossing, that either stand over the bays of the side aisles and east of the transverse aisle, as at Laach and Spires, or west of the crossing aisle as in Paulinzelle (but where the crossing tower is wanting). The combined occurrence of a crossing tower with four developed side towers is rare. The side towers are square, octagonal or circular (Worms), and are covered by wooden or masonry spires, while the crossing tower itself has a slender spire and flatter hip roof (S. Apostles at Cologne), or is crowned by a dome. The side towers were soon extended higher and also the middle structure. If one then considers that also at the ends of the transverse aisle and beside or over the eastern end of the church occur single or pairs of towers or turrets, then the diversity of the forms of the towers of the eastern half leaves nothing further to be desired.

Towers of the western facade.

Almost as many changes occurred at the west facade, even if less in plan than in elevation. While the Italian basilica

uusally had a simple wall in front, before which at most was p placed a vestibule or a forecourt, German and French churches usually already at an early time exhibit a western high structure transversely, perhaps to be referred to the design of the double choir. In the simplest case the stairs are placed in the interior without external indication and are covered at top by a straight transverse roof.

Far more animated is the structure if it rises somewhat at t the middle (Fig. 1342, cathedral at Minden), whereby is obtained the first stage of the development of a "simple" middle tower which rises at any increased height on the transverse building, either simply placed on it or organically prepared for beneath.

A different process of development is taken by the western b building, when stair towers are arranged at its sides (Fig. 1342 a). As soon as these rise higher, the germ is planted for the development of two western towers (Fig. 1343, Liebfrauen c church at Maestricht).

On the abbey church at Laach at the same time appears a middle tower placed on it and two attached round towers (Fig.1346). This richness is explained by this, that the double tower of t the church at Laach has retained for the front building rather the character of the transverse aisle (see Mayence). Elsewhere the three towers for the western structure described are rare, more frequently it occurs already, that the transverse building is connected with a high middle tower and to this are directly added side towers.(Thus in the cathedral at Paderborn, Fig.1347).

The single western tower naturally occurs in the small churches with single aisles, while the great churches with several a aisles, city churches and especially the cathedrals with few exceptions (like Paderborn, Freiburg and Ulm) have received two western towers.

The two towers can extend up with the transvarse building in a single mass without a prominent vertical oh horizontal subdivision, as in many old buildings in lower Saxony (Fig. 1344, Neuwerk church at Goslar); or they stand on a cornice at the height of the eaves of the transverse structure, as on the parish church of Andernach, or finally already appear from below as an independent mass, whether by supporting vertical projections or buttresses, by a projection op the middle structure , (Jerichow), or by the projection of the fronts of the towers.

This separation of the towers from their intermediate building already occurs in the early time and toward the end of the Romanesque time creates greater value, until it attains a general predominance in the Gothic. Thus the intermediate structure can retain its transverse roof, that was particularly the case long in lower Saxony, or the gable of the middle aisle can appear on the west facade, as it shows itself quite early on Rhenish, south German, south French and Norman churches. As an example see Fig. 1345, church at Gebweiler.

Form of plan of western towers.

The form of plan of the old stone towers was generally round (S. Vitale at Ravenna, Aix-la-Chapelle), but circular bell tow- also occur (Ravenna); round towers are frequently found on the Rhine in Germany, but as a rule the rectangular form is general for Romanesque towers, which rise above without change to the toop roof or to a square spire rising from the gables. It is worthy of consideration that the churches of lower Saxony already very early show a transition to the octagon, whether high a above as on the foundation church at Königslutter, or far below as on the cathedral at Brunswick and the Neuwerke church at Goslar (Fig. 1344).

A division into stories is usually not expressed on many Early Christian and Romanesque towers, but they rise from below to the top without belt cornices (Königslutter) and are animated by windows or openings for sound, whose dimensions increase upward. Also is frequently found an undivided extension to the height of the middle aisle, and from there a division in two or three more open stories. Finally there already occurs in the e early time, but more generally in the Late Romanesque division of art a division of the stories from below upward, where the number of stories usually lies between four and six (east towers at Bamberg, tower at Pisa; bell tower at Pomposa has even ten stories). Gothic cathedrals mostly return to 4 high stories of towers, which are connected with the church in a proper relation.

Towers in the Gothic period.

The division of the towers has generally become tolerably clear with the entrance of Gothic, the contest was decided in favor of the west facade, which received one or two high towers, and on the contrary the east end developed its magnificence in

a rich and charming grouping of the transverse aisle and the e ending of the choir, to which in great works was added a circle of decorative chapels. Thus the direction of the church from west to east was clearly expressed. Compared with the rich choir ending the importance of the crossing internally and externally didinished, and it therefore remained without special characterization or was satisfied with a small and slender roof turret. Larger Gothic towers over the intersection occur somewhat more commonly, aside from central churches, only in certain countries (England); Germany has but few examples to exhibit (church S. Katherine at Oppenheim, S. Thomas in Strasburg). On the whole the wealth in towers in the Gothic time issomewhat restricted, one or two principal towers dominate the building, other small crowning turrets or star towers only serving to animate the separate parts of the structure.

Where particular circumstances lead thereto, whether based on the locality or the internal organism of the building, men did not fear unsymmetrical forms of towers.

Generally the abundance of towers is an indication of the importance of the House of god; while the smaller churches of the orders according to the existing simplicity were usually contented with a roof or gable turret, and village churcher mostly received a plain western tower rising a little above the church, city churches and cathedrals competed in the grandest development of towers, which have come to us completed only in the smaller part, and mostly have been compelled to yield to the taste of later times, or have never been finished, since the high aims of the first builder were no longer understood by his successors.

2. Division of the towers into stories.

Relation to the church.

The connection of the towers with the church leads to a harmony or even to definite relations of the two. Since by organic development the horizontal divisions are carried out as nearly uniform as possible on all parts of the church, the position of the towers on the church has little influence in this respect, thus a tower placed before the middle aisle has substantially the same treatment in elevation as the double towers lying before the side aisles.

Number of stories.

On the basilicas the towers usually have four stories, the

first corresponding to the side aisles, and the succeeding one to the lofty middle aisle. The third story carries the tower above the height of the roof of the middle aisle, and the next leaves all parts of the church below it and finally contains the bells, forming the transition to the spire; for this reason it frequently changes to the octagonal form. Particularly clearly is expressed the division in four stories in the double towers at Rheims, Cologne, Strasburg, and in the single tower at Ulm. But the division into four, or if the spire is counted, into five parts in height is not absolutely fixed, there is also found a combination of two stories, as well as into several subordinate parts. Particularly common and with full justification is shown the height of the roof of the side aisle or of the triforium as a subordinate division of the second story, or as an independent smaller intermediate division, as at Amiens, Paris and Mantes (Fig. 939). Where the side aisle has galleries, its second division extends to the tower as at Limburg; similarly on the church of S. Elisabeth at Marburg the division of the side aisle is carried out, while in consequence of the hall form above is omitted one division, as generally on hall churches t the simpler division in height is also shown on the tower. The two upper stories of the tower were often combined into one, a and also indeed the fourth was suppressed in favor of a rich transition to the spire, as on the cathedral of Seez.

Heights of stories.

The heights of the stories can be entirely or approximately equal as at Ulm and Cologne, or they may gradually increase upward or conversely show a diminution upward. Beautiful is also an alternation of low and high parts, especially if thereby occurs an enhancement upward. Finally by a strong prominence of one story may be produced a happy effect (Marburg). All these solutions are represented by beautiful examples.

The two lowest stories.

The lowest story.

The interior of the lowest story of the tower, as indicated by the treatment of the plan, is either separated from the church and serves as a vestibule, or it belongs to the interior of it. In the first case all free sides of the tower are opened, or as in Freiberg only the western has an arched opening, the portal proper being found in the east side. But the angle piers

are always to be regarded as the essential supports of the entire tower.

Thh height of the vestibule is determined by the arrangement of a clearstory, by that of the side aisles, by aisles of equal height and galleries built over the side aisles, by the height of the gallery floor, or with two rows of windows, by that of the passage before the upper series of windows. The reasons therefore result from the requirement of communication with the triforiums on both sides, passages or galleries. Further must for the same reasons the heights of the two lower stories of the towers together equal that of the middle aisle.

Second story opened to the exterior.

If this concerns a middle tower, the second storw forms a vaulted hall, which is either included in the interior or is closed from the church, so that the west window abuts against the east wall of the tower and the other three walls are opened by cross arches. Then the hall is opened externally like a second vestibule and serves to admit light to the window in the aisle.

In the last case the floor of the upper hall will be constructed so that the water coming in through the arched openings shall not injure the lower vaults, and may be easily removed by means of gutters and spouts. We are unable to mention examples of this kind of towers over the middle aisle, but still this plan is found over certain French side aisles, certainly the grandest of all.

Second story open to the interior.

If the tower opens into the interior of the church, then a v vault will be formed below in it corresponding to the vault of a vestibule, which is entirely made open to the interior, or can be changed into a closed vestibule by later closed doors. The story above this forms a balcony open to the middle aisle, that recently is mostly occupied by the organ or the choir of singers.

Under the assumption of sufficient dimensions of the angle p piers, the window may occupy the entire width between them. Indeed by a reduction of its width to less than that of the openings of the doors may the stability be rather increased, since the overlying masses of wall increase the thrust of the arches of the doors.

Where a lesser width of the window is required, as this may

be partly by the simplicity of the entire design, partly may o occur by installing the organ in the second story of the tower, blind panels are then in place to reduce the upper mass of the wall, and they may be visible enternally or externally.

Combination of the lower stories in the interior.

When the need of such a gallery does not exist, particularly in small single aisled or hall churches, then may both stories be combined into a single free interior with the height of the middle aisle. The architectural system of the church, thus being with a clearstory, the triforium and upper windows, will then be carried around in the tower the same as in all other parts of the church. But there the continuation of the triforium in some cases may better be by an internal or external corbelling around the angle pier, then effected by an opening therein. Direct examples of the sort of mediaeval works we are unable to mention, yet there may appear for it the tolerably analogous case of the central tower of S. Maclou in Rouen (Fig. 1348), in which a passage arranged above the vaults of the middle aisle over the isdes of the square and within the thickness of the wall is arranged before the angle piers and a corbelling over the fourth part of an octagon in the plan. An application to the present case would be nearly given by the plan represented in Fig. 1349. This can be changed as in Fig. 1349 a, so that the passage from the triforium outward is on a corbelling a arranged above the vaults of the side aisle, and cut through the gable wall at c, and then either back through the tower wall to an inner triforium, or as Fig. 1349 a shows, it continues on t the outer side of the tower.

In any case also results an intermediate division from the c continuation of the triforium between the portal story and the clearstory, that naturally must assume a different form, according as the rear wall of the triforium or passage is placed inside or outside, opened by windows or closed. Further there results as on the gable walls, on the sill of the clearstory window a second passage supported by the lower one. But just as n noted for the gable on p. 419, the proportions of the heights may lead to an omission of the upper passage, and therefore an extension of the window openings to the sill of the lower one, thus leading to the same arrangement, that results from the division of the side aisles or side aisle walls in hall churches.

If that division fails in hall churches or single-aisled churches, then ff it is not assumed in the tower, the upper window goes down to the gable, or there even occurs the arrangement in connection with the portal given on p. 556.

Combination of the lower stories on the exterior.

If we then transfer the portal and the windowof the middle a aisle to the eastern wall of the tower, then may result a vestibule of a height equal to thea of the middle aisle, that opens externally by arches of equal height. Such an arrangement is defective for different reasons. First the purpose of the covering of the vestibule by the disproportion of the height of the opening to the depth of the room in our climate is brought in question in the same way as in the antique columnar porticos arranged according to the usual rule, second the idea of the vestibule raised to the same height as the interior, third the effect of the other parts of the elevation as influenced by the height of these openings.

As already stated above, everything said heretofore also applies to the double towers placed before the side aisles.

The lower story in double towers.

If here the lower story in the tower usually has the same height as the side aisles and the height of the upper is determined by the height of the vault of the middle aisle, yet there is also formed sometimes ar in the cathedral of Noyon, the combination of both divisions in height made by the omission of t that intermediate vault, just as in the tower placed before the middle aisle. Hence these rooms in the tower in connection with the western bay of the middle aisle form a sort of western transverse aisle, that according to the ground areas of the towers either extends north and south before the fronts of the side aisles, or thus plays a part otherwise entirely similar to the actual transverse aisle.

The rooms in the towers thus open below toward the side aisles and above into the bay of the middle aisle lying between them by corresponding arched openings, the triforiums continue on t three sides of the towers, and stand in connection with another in the western gable wall, and likewise the three sides of above towers opened by windows. From hall churches with two story side aisles or side aisle walls also result here the corresponding arrangement, thus either an intermediate vault or a simple cas-

passage. Yet as for the towers before the middle aisle there c can also here be built balconies in the towers, if then are wanting in the side aisles as in S. Elisabeth at Marburg.

The third story of the tower.

The succeeding story of the tower, thus the third if we pass over the division belonging to the triforium, first fulfils the purpose of raising the belfry above the roof of the church, so that the sound of the bells can spread at the sides, and thus forms the substructure of the belfry, accordingly usually containing the lower part of the bell cage.

Therefore the next determination of height results from the height of the roof, yet there is no direct urgency for it, and there are found examples with variations upward and downward. With only one western tower the church roof adjoins the eastern wall of this story, and for hall churches must also project into the next story, if it extends over the entire width of the nave

Passages and external arcades.

This story is most subordinate of all and appears rather as an intermediate story between the lower part of the tower belonging to the aisles and the belfry. On simpler works it therefore exhibits only cosled walls scarcely opened by windows, which however may be made lighter by internal blind panels. The external recession of the face of the wall from that of the lower story, that results from the offset in the thickness of the wall, is most simply formed by a wash, but in larger dimensions may also serve for the arrangement of a passage connecting the roof galleries at both sides, and is furnished with a closed or opened balustrade, and thus provides a richer termination for the lower part of the tower. From this results a motive capable of very important and most varied treatment for development of the elevation. let us assume that above this story is arranged a second passage at the base of the belfry, which certainly can almost be required as an extension of the room occupied by the latter, and then the thickness of the wall scarcely permits another offset sufficing for this. Therefore occurs either a corbelling of the upper passage, or the utilizing of the lower recession for an arcade standing on its edge to support the upper floor slabs in the same manner, that in the aisles the passage found before the clearstory windows is borne by the arcade columns of the t triforium, or like the floor of the latter on the gable walls

of the tsansverse aisle on the arcade columns of the passage before the lower windows finds its bearing (p. 419), and constructions executed there are also employable here. Examples of this kind are presented by the cathedrals of Paris and the collegiate church in Mantes (Fig. 939).

With doupled towers the roof of the middle aisle can then extend to the front side, yet there the gutter between the towers must be farther inward, and therefore be placed higher than at the longer sides of the church. Since it is substantially narrowed py the vertical position of the wall of the tower, it would be better if set back still farther, and from this be arranged a short roof surface next the tower wall. Now since further the removal of the water toward the front through the arcade gallery extending before the west gable and connecting the towers presents some difficulties, this explains the termination of the church roof at the eastern face of the tower, and the arrangement of a terrace over the west bay of the middle aisle, as found on the cathedral of Paris, and which removes all those difficultie

Blind recesses and blind arcades, arched openings.

The wall of the third story of the tower behind the enclosing arcades can be opened by windows, and again be animated effectively by blind arches serving to lessen the mass of the wall. On the cathedral of Paris are arranged on each side of the square of the tower two internal blind arcades, so that the structural system of the story concerned, besides the four angle piers, contains as many middle piers, that stand on the crowns of the arches of the lower windows. Two or more such blind recesses also in the lack of arcades could give the motive of the treatment for the tower story in question, as on the cathedrals of Laon and of Strasburg, on which the blind recesses are placed outside or even become actual arched openings

In the arrangement of blind recesses however, there must in all cases be a certain visible relation both to the openings of the story beneath as well as to that above, and we shall further return ho the investigation of the latter as well as to the possible preparation for the polygonal belfry.

The decorative effect of the passages and arcades around the roof story can be striven for in smaller dimensions, so that with the omission of the passages, the columns quite or nearly adjoin the face of the wall, and are connected to it by capitals

and bases and also by some headers, while the arches turned on them are bonded with the wall. Sometimes the latter also consist of certain slabs facing the wall, but which are made like tracery and are perforated like the scheme of tracery. Further are also common the little columns wrought in the bonded courses, and finally on later works are replaced by mullions without capitals continuing the simple tracery profile of the arches. As a tasteless echo are to be regarded those four angle pilasters connected by an arched frieze, which are commonly found on the simpler towers of the latest period, whose arches rest on corbels, if their moulding is not merely broken around above the lower horizontal division.

The two principal arrangements of the roof story, the arcades and openings of the arlhes essentially differ in their ground character, for the former produces rather a horizontal separation between the stories found above and below it, but on the contrary the latter represents a vertical connection of them in a vertical direction. The use of an arcade is moreover not restricted to the place mentioned here, but can also be arranged on other stories of the tower, and indeed even as a lattice before larger window openings in the wall behind.

The fourth story.

Openings for sound.

The fourth story of the tower contains the bells and is the most important of all, and this must be indicated as such externally by height and treatment' according to its purpose it forms a room covered in different ways, which permits the sound of the bells to pass out through wide and high arched openings.

On those simpler towers belonging to the smaller churches of rubble or brick construction, that are generally but sparingly opened, also the size of the openings for sound are smaller. In every case must here predominate either the mass of the wall as in Fig. 1350, or the sice of the openings as in Fig. 1351. On the larger French towers with belfries of square form, as at Paris, Soissons and Mantes (Fig. 939), there are found at each side two tall arched openings. The advantages of this division in two parts sometimes found already on Romanesque towers are varied and important. If we assume here the horizontal termination of the given tower as originally intended, then the construction of the stone covering, that must be about as in Fig.

96, is made substantially lighter by the bisecting ribs turned between the middle piers. Likewise the depth of the jamb of th pier is far more favorable for the arrangement of the louvres, than the lesser depth of the middle pier required by a single arched opening. Further the desired character of the entire construction of the tower is enhanced by that vertical division, and the possibility of a lesser height is obtained from it, than would be required for a single arched opening filling the entire width. On other French towers, like those at Noyon and at Dormans in Champagne, are further found three arched openings at each side, that were also taken from the Romanesque.

Then for one, two or three openings, it is in the same manner to make the escape of sound as perfect as possible.

As already stated above, there is a certain relation between the arched openings of the different stories, and then is necessary a distinction of them from each other, according to their importance. The belfry is indicated even by those numerous free arched openings above the closed wall surfaces or arcades of t the lower stories, as shown in Fig. 939. But this effect is substantially weakened, if the lower story exhibits the same division in a competing manner. Therefore if the same division into two parts is usually assumed for both stories, the lower story must be distinguished from the upper by smaller height and lesser size of the openings, which is the case in many Romanesque and Early Gothic examples, or which is especially preferable in smaller proportions, there must be a combination of the triforium and window, analagous to that mentioned on p 407, about according to Fig. 1352. This is found also on the Freiberg tower, though in a changed condition.

Relation of the openings of the different stories.

But also a vertical division of the uppermost story by a free or attached arcade could be made, or even by mere blind arches, with the assumption that this is not already found in the same manner in the story beneath. Generally the superposition of different arrangements, yet suited to and in a sense requiring each other, produces a characteristic motive of Gothic tower construction, opposed to the not rare and quite too similar repetition on Romanesque towers in Germany and Italy, that is injurious to good effect, as it is contrary to the nature of the matter.

While the heights of the other stories in a sense are determined by the different divisions of the height of the church, s such a limitation vanishes from the belfry. In the simple buildings with great closed wall surfaces, that predominate in Germany at least in the country, the height varies from about the half diagonal of the external square of the plan to its rarely exceeded side. More slender proportions up to twice the side are found only on richer works, and already belong rather to an expressed pier construction.

Variations from the given division of stories.

Every heretofore assumed division of the tower into four stories must not be too strictly taken, as it lies in the nature of the matter and in the conception of artistic freedom, but as already mentioned at the beginning of this Chapter it may suffer many changes, yet where must always remain the suitability of the church. We have already mentioned the combination of the portal story with the window story resulting from the hall church, and have given in Fig. 1352 an example for an at least formal combination of the two upper stories, which according to t the conditions can be extended to an actual one. Further by simpler construction and smaller proportions the entire tower would remain undivided up to beneath the belfry, and the latter could even be placed in the spire, as will be shown later.

An increase in the divisions in height is already contained in the mentioned carrying of the triforium around in the tower walls, and is even enhanced on the towers of Amiens, since above the triforium is found a second lower arcade balustrade, in which the intervals between the columns are filled by figures, whose heights form the difference between the heights of the clearstory windowsin the nave and that of the western base window

But also the fully justified equal division results from the arrangement of vaulted galleries over the side aisles, as on the towers of Mantes (Fig. 939), and it would be here the connected arrangement of the triforium lacking in Mantes, that would increase by one the number of divisions by carrying it around the tower.

Further subordinate divisions are also found on the higher s stories as in Freiberg, where the proper belfry is contained in such a subordinate division of the uppermost story of the tower, an arrangement to which we shall later return.

Upper termination of the towers.

Towers without spires.

The most common termination of a tower is a pyramidal spire (p. 580), but the simplest is a horizontal ending, thus the covering of the belfry by a terrace, which is most naturally formed by a layer of stone slabs, but is replaced on the cathedral of Paris by a low hip roof covered by lead with a passage extending around this. In every case there results for flat roofed towers a tracery balustrade above a more or less richly formed but bold roof cornice. To secure that balustrade pinnacles are then usually set at regular distancer (Fig. 939), which at the same time animate the horizontal termination. The same effect is then obtained in a higher degree by the endings of the buttresses, or most perfectly by the arrangement of angle turrets.

Stair towers on them.

The latter are required by the necessity for stairs leading to the upper terrace. But thereby results a substantial difference, according to the different positions of the towers. Thus a tower placed before the middle aisle with the assumption of a horizontal termination, at least two such corner towers, and indeed the second are required for esthetic reasons, since thereby the effect of the gable facade is calculated for the culmination in the high architecture at the middle, which effect would necessarily be injured by the one-sided height of one corner. On the other hand the effect of a central tower with a horizontal temmination in which culminates thus the entire church building at the sides, which would be disturbed by every departure from the concentric symmetry, and hence four corner towers are required here.

For double towers the need of a symmetrical treatment vanishes, since these do not express an architectural independence for themselves, but first in combination with the entire gable facade, they can be content with a stair tower for each at the inside or outside corner, and generally suffer departures from symmetry in details. Thus we see the towers of Mantes (Fig. 939) treated almost symmetrically up to the story corresponding to the clearstory of the church. But above the latter the symmetry is so far annulled by the turrets on the outside corner piers and the arcades surrounding them, that the middle pier of the double openings for sound in the belfry are moved to the middle

line of the lower window or the entire side of the tower.

Comparison of towers with and without spires.

The termination that results from a horizontal covering of t the towers is always stronger, so that it usually seems doubtful, whether according to the original plans a pyramidal roof was intended for towers now covered by terraces. But the contrary is here expressed first by the great number of those, that in any case must allow it to appear as a singular accident, that all should be completed directly to the placing of the spire, as well as the fact, that this form of tower is restricted to France, Belgium and England, and was never produced by the same conditions in Germany. But the most important reason for the originality of the form is, that on all towers of greater importance and finer execution, the reception of the spire is prepared for by the entire form of the belfry in a way so that both parts require each other. But such preparation in the ground form of the belfry does not fail alone in the towers in question, but the placing of the spire is even substantially made more difficult by those variations from the symmetrical design as thus at Mantes, but are found more decidedly on the towers of S. Gudule in Brussels, whereby the middle line of the vertical part of the wall differs from that necessarily belonging to the entire tower, and thus over the middle of the ground square, or yet the ground form of the spire set on the belfry fall entirely s separate, thus making any organic connection impossible. Perhaps in the no small number of towers in Normandy with which are to be counted certain in England, on which a spire is unsymmetrically placed, rather the latter must appear as subsequent by the ornamentation produced by the amgnificence of other French towers

3. Basal forms of spires and transitions to them.

Spires of round and polygonal towers.

Conical and domical roofs.

Round towers almost without exception have round roofs, and these may have the form of cones, low or steep domes or also t that of a spire with concave sides. As exceptions are to be mentioned the side towers of the abbey church at Laach, that with the circular form have received octagonal spires; the transition to the octagon is made in the arched frieze of the main cornic

Pyramidal spires.

Polygonal towers seldom exhibit a polygonal dome (like the c

churches of Bari and Lecce), but more commonly a round one like Notre Dame at Avignon, S. Honorat at Arles, etc., but generally pyramidal spires with the number of sides of the tower. The latter also frequently occur as stone roofs as those of wooden construction, those covered with metal, slate or tiles; their effect depends very much on the inclination of their sides (Figs. 1353, 1354). In Romanesque times also occur both low hip roofs with height less than width, and that are particularly suitable for wider towers, as well as also spires with pronounced tendency in height, but which usually do not exceed the proportion in height of 2 to 1. Gothic spires become more slender; a height exceeding 4 times the width can pass as an average value, and this is found tolerably exact on the towers of Cologne, Ulg and S. Denis. Somewhat lower are the spires at Chartres, Freiburg (3 3/4), but on the contrary more slender are those at Seez and Marburg. A proportion of 5 : 1 is indeed rare, yet certain old and new towers also notably exceed this, especially the ornamental roof turrets, the spire of the cathrdral of S. Stephen at Vienna evey received the inclination lying between 6 and 7 :1.

The pyramid can extend to the outer edge of the wall of the tower or be set back somewhat from it, when the recession is c covered by a lower inclination (Fig. 1355), is concave (Fig. 1355 a), or has a horizontal passage (Fig. 1355 b). All eight sides may receive gables (Fig. 13565 as examples may be mentioned the crossing towers at Sinzig and Limburg), if the four principal sides are to be accented, these may alone be ornamented by gables, also if they are wider than the other sides . (Fig. 1357, S. Eusebe at Auxerre). An entirely different form of spire is found by rotating the pyramid 22 1/2°, so that its angles then appear at the apex of the gable, Fig. 1358, crossing tower at Bonn.

Star-shaped plan of spire.

If the line of junction of the surfaces of the spire coincides with the vertex of the gable (Fig. 1358) or is to be parallel to it (Fig. 1358 .), then the height of the spire depends on the height of the gable, and it must be about 6 4/5 times the height of the gable measured in the plane of junction. (h in Fig. 1358 a With the inclination for the gable of 45° there results from this a height of the spire that amounts to about 1 1/2 times its width, but for 60° to about 2 1/2 times the width. A steeper spire

either leads to a horizontal break in the line a b (Fig. 1358 a) or gives opportunity for a recession downward of the junction line a c (Fig. 1358 c) from the apex of the gable, the latter solution with the lower spire is not very satisfactory, the first one with an angle above the apex of the gable is just ugly and allows the spire to appear stunted. To avoid both, probably men came to the peculiar Romanesque form of spire with alternating hips and valleys represented in Fig. 1359, which is generally found on the Rhine (S. Apostles at Cologne), both for octagonal and square towers, and it is even transferred to the choir polygon (Münstermayfeld). Such roofs are built of wood without difficulty, but for stone the valleys must be strengthened, or still better be supported by steep arches placed beneath them. The valley may also be replaced by a flat rounding.

Spires of square towers.

Gable or hip roofs.

A rectangular tower can be covered by a gable oh hip roof with or without a ridge turret, but this particularly suitable covering for rectangular plans is rather restricted to secular buildings, aside from the oldest towers and later village churches. The most natural and simplest covering is also afforded here by the pyramidal roof (Fig. 1360), it can be made octagonal or curved at the base (Fig. 1355); on the other hand the Romanesque rectangular stone spire sometimes is swelled with great advantage for static reasons (Fig. 1361), which by a greater curvature passes into the square hipped dome, Fig. 1362, monastery church near Zambek (See Kunstdenkmäler der Öterreiches Kaiserstattes).

Above the four sides the spire may again be placed gables; if at the same time the spire be rotated 45°, so that its hips meet the apexes of the four gables, there result the very common forms of Romanesque terminations of towers represented in Figs. 1363, 1364 (Halberstadt, Limburg, Laach, Coblenz, Maestricht, etc.). The height of the spire in the regular construction amounts to twice the height of the gable, and the four sides of t the spire are regular lozenges. Variations of the relations of inclination between spire and gable are made as for octagonal towers, Figs. 1358 to 1358 d.

Other forms of roof.

Also folded roofs (Fig. 1365) can occur over the skuare. To the last are closely allied intersections of gable roofs (Fig.

1366), as such are found at Paderborn (Fig. 134/) and on the market church at Hanover, in the last example having an almost necessary roof turret at the middle.

Figs. 1364 to 1367 are nearly allied in spite of their apparent diversity, since they all result because straight lines (rafters) extend from the base points c and apexes a and b of the gables to the apex of the spire. If the height of the spire be twice as great as the height of the gable there results Fig. 1364, but if it is 1 : 3 times as high then occurs Fig. 1365, but if they are equal then is produced the valley roof in Fig. 1366, and if the spire is more then twice the height of the gable, there finally results an octagonal pyramid, Fig. 1367. (On its angles at the edges and slenderness, see p. 584 below).

As an exceptional form may be mentioned the folded roof over the twin gables of S. Gereon at Cologne (Fig. 1368).

The last examples (Figs. 1365 to 1368) exhibit changes from the square to richer ground forms of roofs, so that we have thereby come to a Chapter which occupies a particularly prominent place in the history of the development of tower construction. Rectangular spires present structural differences in construction in stone (see below) and besides by changing the point of sight it makes a greatlv varying outline not equally favorable from all sides, which is easiln explained, when one remembers that a square seen diagonally is 1.414 times as wide as the side, thus a spire when viewed in front has the proportion of 4 : 1, but only shows diagonally that of 2.8 : 1. But since the masters in the middle ages more than those of any other time designed no flat architecture (the So-called facades) but masses of building occupying space, they were extremely refined in feeling on this point. Therefore they transformed at least the roof and very frequently the entire upper portion of the square tower into a more central form; sometimes the circular plan occurs in the form of domes and cones, more commonly the polygon and especially the octagon, which is developed most naturally from the square.

Octagonal spires on square towers.

If the square has the defect, as we have seen above, of becoming considerably wider in the diagonal view, this vanishes almost entirely for the octagon, for its diagonal is only 1.082 times as great as its least width, or in other words the diagonal

view is in proportion to the geometrical about as 13 : 12 (instead of 14 : 10 as for the square). A spire that shows a height in the proportion of 4 : 1 in front view cannot appear less than 3.7 to 1 when seen diagonally.

Consequently if on a square there be placed an octagonal spire the spire is helped as such, but more prominently appears another defect in the diagonal view. for just as the spire in this view shows the least width, but the tower beneath it exhibits its greatest breadth, the direct transition betweentthe two at the angle looks very ugly to the eye (Fig. 1369). If then were reduced somewhat to favor a passage and thus the balustrade of the latter conceals the lower part, the ugly effect would be considerably increased, especially when seen from below.

A good adjustment of both is thus an indisputable requirement, that can be satisfactory in various ways. First in the spire itself can be completed a transition from the square to the octagon, and then intermediate structures can be erected on the free angles, and further an intermediate member may appear between tower and spire, and finally the transition may find its place high above or farther below in the tower itself. All these solutions have been expressed in manifold styles, the most important of which may be briefly stated.

Transition from the square spire to the octagonal one by chamfering.

A transition in the spire itself in the mode of Fig. 1370 and of the corresponding diagonal view in Fig. 1370 a is simplest, if it commences square below, is chamfered at the angles by four oblique planes, so that at the certain height it forms a regular octagon and then continues as an octagonal pyramid. The four angle surfaces have a slight break at the lines a b and c d, w while the four other sides extend in a plane. If the transition in the diagonal view be gradual, then the height e a of the chamfer must not be too little, but should be at least 1/2 or 2/3 of the bottom width of the spire. Frequent mistakes in this respect are made in new towers, so that the transitions are not usually perceived from a low point of sight.

If this transition be made on a spire that has a low inclination below, there results a break in all the eight sides of the spire, Figs. 1371, 1371 a. Aside from the fact that a slight reduction is sometimes justified by a lessening of the thrust, th

effect of the earlier tower does not appear favorable. The transition becomes in the diagonal view again very abrupt, and the height of the spire is thereby reduced unnecessarily. But a high spire particularly contributes to an imposing and beautiful effect of the tower, and besides also for financial reasons the finally determined height of the tower is more advantageously attained by a high spire than by high walls. Yet in later times in the wooden spires of many village churches and secular buildings, the base of the spire has been reduced as much as possible by the use of a flat or curved plinth, but thereby the slenderness of the pyramid is increased. (Fig. 1372). On small ornamental structures such spires are indeed justified, but in any case with the skill by which they are designed, one cannot refuse t them the merit of a certain decision in contrast to many flat new attempts.

Transition by four gables.

The transition from the tower to the spire is facilitated by the existence of four gables over the sides of the tower. A form already approximating this is shown by Fig. 1373. It may be conceived to originate either by supporting the angles of the pyramid in Fig. 1364 or by the ordinary placing of an octagonal pyramid on a square tower by extending downward four pyramidal sides to cut off the corners of the tower. Figs. 1373 a and 1373 b show sections through the sides and the diagonal. If the completed upward, they either rise free from the surface of the spire, as at the left side of Fig. 1374, or its sides intersect like a roof, as in Fig. 1374, at the right. If no break at the height c c is to occur, then the height of the spire is dependent on the height of the gable, and it results from making it twice the height of the gable. If the spire is to be more slender, there occurs a break in the line c c, or the line of junction bends back (Fig. 1374 b). On this see Figs. 1358 a to 1358 c. In the diagonal view such towers of similar outline are as drawn in Fig. 1370 a.

If the transition is to be more continuous, then can the finials or added buttresses shown at the angles in Fig. 1375 or s some other properly formed be placed on the angles to load them with advaytage. The ashlars of the gable cornice assume the rather complicated forms seen in Figs. 1375 b and c. If the apex of the gable projects like a window gable (Fig. 1375 d), then

the ashlar will also receive a corresponding form.

When the base of the spire is reduced, the four gable roofs will project farther, until they finally approach two crossed gables (Fig. 1366) in their effect with a central spire.

Diagonal position of the spire.

By placing the spire diagonally so that four edges stand on the apexes of the gables and the other four on the angles of t the tower, a particularly pleasing general transition is produced in both front and oblique views (Figs. 1377, 1377 a), that is already much found on Romanesque towers. If the line of junction falls on the side of the gable or a parallel to it, then the spire from the lowest point to the highest apex is 3.1414 times as high as the gable. With an inclination of the gable at 45° the height of the spire becomes 1.707 times the side of the square or 1.21 times the diagonal of the square at the bottom a a, but with an inclination of the gable at 60°, it becomes 2.96 times the lower width a a or 2.09 times its diagonal.

If the spire is to be made steeper or flatter, there will occur a break in the line c c, or the line of junction will no l longer be parallel to the edge of the gable. Finally sometimes occurs the following expedient, to vary from the regular octagon, so that at the height c c of the plan of the spire so that the left side of Fig. 1376 corresponds to it, but the right side to a flatter spire. The last variation appears on the towers at Spires and exists on the western building of S. Apostles at Cologne. It is to be noted on this occasion that also above rectangular towers can be erected similar spires with corresponding irregularities. If the spire ever becomes flatter, then finally the point p (Fig. 1376) will fall in the line m n, and consquently from the octagonal spire results the square spire of Fig. 1364, and a further depression of the apex of the spire and a connection of it with the corresponding corner points would finally lead to the folded spire with the star-shaped plan m p'n. (Figs. 1376, 1365). To animate and load the corners also on these towers may again be placed finials or turrets between the gables, that are based on the walls of the tower or partly on the angle buttresses. But the angle turrets are preferably restricted to the width of the gable, and S. Patroclus at Soest presents a very old example of this. The gables were decorated by arched openings, polyfoils, blind arches or tracery, and some-

sometimes the openings for sound in the story of the tower extend into the gables.

Here is also mentioned the peculiar spire of Treysa (Fig. 1410) that has smaller oblique gables between the four principal gables, whose apexes likewise receive the hips of the spire.

Detached angle pyramids.

When the octagonal pyramid rests directly on the square tower horizontally without gables, then there remain free four triangles at the corners (Fig. 1378), and the result of this is the ugly diagonal view, p. 582 and Fig. 1369. If then the covering spires of Figs. 1370 to 1372 are not employed, then to improve the outline and remove water, thin angles must have separate coverings, which are to be harmonized by bold heights with the slenderness of the spire. (The roofing of the tower may be compared with the roofing of a hall church of three aisles, that either has a common roof as a great middle roof with different adjoining side roofs). The triangles may first have angle spires similar to the main spire, which take the form of triangular pyramids. The vertexes of the pyramids may lie over the external corners (e in Fig. 1378), see Figs 1379 and 1380 from the church in Gebweiler, they may fall above the centre of the triangle as at the left in Fig. 1381, or be moved over the middle d of the side of the triangle as in Figs. 1378 and 1381 at right. Fig. 1381 a shows the two last cases in diagonal view, between the main spire and the side spire is formed a sharp line with a little gutter below, best avoided by inserting a little gable roof, as indicated by the dotted line. More simply may be avoided the deep cut by increasing the triangular pyramid to a square pyramid by adding a symmetrical half, which stands over e f g; in Fig. 1378 its rear edge intersecting the surface of the spire at k, as it shows in the diagonal view of Fig. 1382 and a more tasteful effect; the geometrical elevation remains the same. T The effect of such an octagonal spire surrounded by four little angle pyramids, that is found on many German and French towers in stone and wood, is particularly imposing and interesting on account of its simplicityand clearness. Fig. 1384 shows an example of a little subordinate spire of Freiberg minster, that is steeper than the principal spire, but more commonly both have the same inclination.

Attached angle pyramids.

An entirely different result in both views, if the angle pyramid of the form of either Fig. 1381 left or right is connected by a gable roof with the side of the spire rising behind it, as in Figs. 1383, 1383 a left; it appears already as a part belonging to the principal spire, which is more the case if the point s is placed nearer the side of the spire, into which it may finally pass, Figs. 1383, 1383 a right. Thereby is attained the simplest covering of the corner, it may be steeper or flatter as on numerous towers of the early and late times, and approximate in effect again to the common spire of Fig. 1370.

Transition to the octagonal spire by an intermediate piece.

Passage at base of spire.

Although we have seen that it is well possible to properly arrange the square tower with the octagonal pyramid resting thereon, yet this aim can be attained even better, if the transition is already made below the base of the spire (as examples see Fig. 1396 and the right side of the tower at Gebweiler, Fig. 1345). This is attained by a corresponding form of the upper p part of the last story of the tower (belfry), but there can be a small intermediate division rising above the belfry, like a plinth of the spire, and which is especially added if a balustrade exists. As already stated, by recessing the sides of the spire it is next to utilize the space between the sides of the spire and of the tower for the arrangement of an external passage at the base of the spire, which is enclosed by a tracery balustrade,whose angles can be secured by pinnacles, giving a rich ornament to the entire tower.

Since then a greater value is justly placed on the arrangement of such a passage at the considerable height permitting a wider view of the people, we shall here state, that this is possible even with the spire not set back, when the floor slabs of the passage are borne by an arcade standing on the lower part of t the full spire (Fig. 1388). The transition of the square to the octagon beneath the passage remains visible through the arcade.

Interposed sjuare intermediate story.

But a good transition with the recession of the spire and the arrangement of the passage is even more required than otherwise, and it can be placed directly above the passage according to one of the solutions in Figs. 1370 to 1377, or as stated, in a very

effective manner is raised above it by a low story recessed by the width of the passage (Fig. 1385), but otherwise formed according to ann system there described.

If then the loading of the angle pier by a turret is to be t termed structurally favorable, this will in the last case afford the further utility of strengthening the walls of the story inserted, and of briging it into closer connection with the belfry. Likewise will angle turrets almost necessarily produce a beautiful transition on account of the horizontal division caused by the passage.

Both aims will be attained in more complete measure by pinnacles corresponding about to the thickness of the wall or even exceeding it. These may partly stand on the buttresses, if the latter extend the full height of the belfry.

The southern of the Marburg towers has square and the northern octagonal pinnacles. The square ones (Fig. 1389) have the width of the buttresses and with them project somewhat from the face of the wall, the octagonal ones being wider than the buttresses (Fig. 1389 a), so that the outer side lying on the diagonal is corbelled out over the angle between the two buttresses. The r rear angle of the pinnacles coincides with the angle of the recessed story, except that below is an opening to provide a passage (Figs. 1389, 1389 a).

A similar but simpler arrangement with buttresses extending higher os shown by the tower of the Frankenberg church, on which indeed instead of the originally intended stone spire was m merely erected a temporary roof, so that we must restore in Figs 1387 and 1387 a the added spire as well as the ends of the buttresses.

On later works the dimensions of the pinnacles placed either on the buttresses or the angles of the walls are frequently reduced, so that they stand entirely free before the walls of that recessed story, and therefore are without structural importance for it.

Yet a connection is sometimes arranged, which is rather merely for the security of the more ornamental pinnacles, than for the angles of the wall, and consists of arches or flying buttresses turned diagonally, or is made by channels for water passing through the pinnacles. Examples of this kind are indeed shown in a changed form by the towers of Wildungen (Fig. 1388) and of

Volkmarsen. However the effect of this arrangement is still very picturesque, even if it does not bear comparison with the older examples.

Octagonal intermediate story.

The necessity for this transition from the square to the octagon can be avoided if the upper recessed story be made octagonal. However the effect is not favorable, especially in the diagonal view, since the angles of the square tower form an excessive p projection, and when seen from below conceal a great part of the upper story (Fig. 1391). In any case this design requires longer angle pinnacles, and if a connection of these with the angles of the octagon becomes preferable, about as in Fig. 1390.

One should not fail to indicate, that an optical illusion aids the unpleasing effect. For physiolical and psychological reasons not to be explained here, acute angles generally seem to us less acute and obtuse angles less obtuse, than they really are, which has the result that the tower in Fig. 1391 appears to have the outline in Fig. 1391 a, i.e., both the tower and the intermediate story appear to widen upward. The inclination of the walls and even the inclined positions of the columns on German towers must in part be based on similar phenomena; besides the almost constantly employed battering of the walls upward or recession in offsets, the middle ages had an effective means in the buttresses strongly enlarged downward. In the particular case occurring here, also much can be accomplished by angle pinnacles or other transitions at the points in question.

Defects of an intermediate story above the passage.

If the intermediate story be very low or be entirely wanting, there appears in the diagonal view the effect shown in Fig. 1369, but still more increased, since already the tower spire is reduced at each side by the width of the passage. Therefore this solution is to be termed less favorable; yet where it came into use, it required the more skilful treatment. As an example may be mentioned the tower of the Teyn church at Prague.

Here the transition is made by four octagonal angle turrets with pointed spires set on the angles of the belfry and strongly corbelled out, that are connected with the great spire by projecting roofs placed diagonally. If then also the entire tower more nearly approaches a secular character by that great projection of the angle turrets with the passage, yet just this arrangement

is in the finest harmony with that represented in Fig. 1472, a and further the turrets corbelled out above on the spire, and this arouses the most vivid surprise, that the master understood how to produce such a picturesque effect on the basis of an unfavorable motive by the consistency of the development.

Angle turrets at the height of the base of the spire.

The effect of an intermediate part inserted between tower and spire is thereby attained, even if only apparently, so that the angle pyramids represented in Fig. 1382 are raised above the b base of the tower by a plinth with vertical sides or an arcade, thus being made an actual turret (Fig. 1392). These may also a appear in direct connection with the buttresses, if two of its angle piers stand on them as shown in Fig. 1393, so that a diagonal square results for the angle turrets . Then the buttresses either terminate in the returned cornice of the belfry or below them by a slant, the latter being placed on the angle pier below the cornice of the belfry.

Then there results for these angle turrets the ground form of the octagon, if they rest with two piers on each buttress (Fig. 1393 a), so that thus the width of the buttress agrees with a side of the octagon. The angle left between the buttresses may then be filled by corbelling as shown in Fig. 1394, so that it forms an enlargement of the octagon. This transition then resultus more readily, if as in Fig. 1393 a the buttresses are removed from the angles of the square, so that the latter forms a single or double offset between them.

Such a design is found on certain French towers, but were intended on others like Noyon and Soissons, as may be recognized with certainty, and on that last named at least in the form of little angle balconies projecting from the terminal terrace and carried a few steps above their floors as constructed.

The interiors of such open angle turrets receive a horizontal floor, from which the water is removed by spouts, and made accessible by doorways opened in the diagonal walls of the spire. According to the ground form of the whole there may still remain small horizontal surfaces between these little angle turrets, affording for the arrangement of gargoyles beneath the angles of the spire.

With these angle turrets may again be combined passages at the base of the spire, that lead through the angle turrets, or exten

around them on corbelling. The last arrangement is found on a tower at Louvain belonging to the late time of Gothic, in the manner that the closed angle turrets are placed on the buttresses, and the passage is corbelled out around them. The perforated spire with tracery begins behind with a square base, but changes into the octagon directly from the floor of the passage by a transition formed according to Fig. 1370.

Dormer windows on the four sides.

On French towers the effect produced by the angle turrets is usually only enhanced by this, that on the sides of the spire parallel to the square are built dormers likewise at the height of the base, but of such slender proportions, that they form a crown with the angle turrets, from which rises the spire of the tower in a very stately manner. These dormers are then either terminated by spires, as a rule rectangular, or by pointed gables, that however stand free, so that their rear surface is either a vertical surface or a steep hip. In both cases a gutter lies between it and the spire (Fig. 1392).

Angle turrets on wooden spires.

On many simpler towers without buttresses, and as a rule on those with wooden spires, the angle turrets are partly corbelled out, and then and then either built of masonry as on the tower of S. Peter in Lübeck, or constructed of wood like the spire as on a great number of village churches in Hesse. There the floor of the spire is utilized by the projection of certain beams or tiebeams for corbelling; the angle turrets themselves a are made octagonal or still more frequently are hexagonal, opened by a doorway to the spire and by small dormers on the free sides, and covered by slates like the spire (Fig. 1395).

The same motive of corbelling by projecting ends of beams is sometimes employed in smalles dimensions also for making the transition from the square tower to the polygonal spire. (Fig. 1475).

Transition of the upper part of the tower (belfry) to the octagon.

The transition from the square tower to the octagonal spire is made considerably easier, if it can be completed in the tower, so that the upper part and particularly the belfry is already octagonal, but it is only possible when sufficient space remains for the hanging and the movement of the bells.

Internal transition to the octagon, corbelling above.

As an intermediate stage between the square and polygonal belfry may be those arrangements, in whilh is either found over t the belfry a low and recessed octagonal story (Figs. 1387, 1388), or the transition to the octagon is below the base of the spire in the mode of Fig. 1396, or is similarly effected. In both cases the walls of the sides falling in a diagonal direction partly stand over vacancies, as indeed the case in like manner for the walls of the spire, but here by a continuation of the inclination of the spire inside to the square, it may be most easily attained (Fig. 1413). The vertical walls of the octagon in a d diagonal direction, that according to their height exert a greater pressure downward, in the same manner may be placed on steep corbellings, and as a rule are however supported by spherical or conical surfaces (Figs. 1397 to 1399) or by arches (Figs. 1400 to 1402).

The latter consist of two or more concentric courses, which are turned between the internal faces of the walls of the belfry and are either corbelled out with their square springings or rest on a projection of the wall. Figs. 1400 and 1400 a show the latter arrangement from the towers of the Liebfrauen church in Worms. These arches thus transfer the load partly sidewise to the walls of the belfry, but partly to one another and thus finally to the angle. On Freiberg tower is found a similar arrangement, except that the separate courses of the arch do not join by horizontal but by inclined bed joints with each other, and thus approximate the form of half domes or of domical segments (Fig. 1405).

Fig. 1401 exhibits the corbelling in the cathedral tower at Paderborn (after a communication from Building Councillor Güldenpfennig there). The arches there partly rest on a projection from the wall, partly spring obliquely from the wall. With round or pointed arches the parts of the arches projecting from the face of the wall could be supported by corbels or little columns. Fig. 1402 shows both, and also in the lower part is a very frequently occurring corbelling like a pendentive. Especially varied transitions are shown by the higher dormers in the crossing towers of Rhenish and French Romanesque buildings, from which are also taken Figs. 1397 to 1399.

Internally octagonal and square belfries.

By extending these transition vaults beneath the floor of the belfry there results for it then the octagonal ground form, which however is unfavorable for arranging the bell cage and may limit the space possibly required for swinging the bells. Therefore on certain French towers as at Chartres and Rheims, the octagonal belfry is henceforth connected with the angle turrets standing at the height of the floor, and here forming the transition to the square; by means of the arched openings that are in the sides of the octagon lying diagonally, so that at least for the interior of the belfry the square plan is again obtained (Fig. 1394 a).

Form of the angle turrets.

Each angle turret then stands at the height of the floor of the belfry directly on the buttress, as elsewhere at the height of the base of the spire, and is capable of the most varied forms. What first concerns the height, it can have the same height as the belfry (Fig. 1394), thus being surrounded by its cornices in Rheims and Laon, and above these being directly crowned by spires, which arrangement was at least intended in the works mentioned. Instead of these low stories could still be placed above the cornice to support the spire, or finally the angle turrets could be lower than the belfry, so that there as pinnacles may adjoin its walls in part or for their entire height, as in Senlis and Chartres.

They can further for their entire height be formed of continuous little columns connected by arches is in Rheims, or be separated into two stories by a floor as in Laon and the cathedral of Naumburg. These stories may have the same ground form as in Naumburg, or differ from each other as in Laon, where on the lower one formed as a square set diagonally rests the upper one composed of five sides of an octagon, whereby however the upper story is not accessible, and therefore its floor is beset by c colossal animals looking outward between the little columns.

Stair towers.

One of the angle towers can enclose a stair tower leading to the height of the base of the spire, either so that it has its separate walls or piers, within which the pier of the angle tower stands as in a cage as in Rheims and Senlis, or so that the steps and strings are borne directly by the piers of the angle tower, as on some later works to which we shall return later.

It is here allowable for the stair tower to replace the angle tower at one corner, and by its different form make a change f from the symmetry.

If we have designated the angle tower above as usable for the arrangement of an internally square belfry, this use has not always been made of it, and in Laon and Senlis only the diagonal sides of the octagon open to the angle tower by doorways, so that by the little towers besides the obtaining of covered porches is received only the utility of loading the angles.

Tower at Freiberg.

On the tower of Freiberg minster is found a peculiarly spirited change in the motive of the angle turrets corresponding to all requirements in the most beautiful way, into which we must enter more fully.

As already stated, the purpose of the little towers is manifold, they serve to establish the square ground form of the interior, to load the corners and at the same time to form the transition from the square to the octagon. Accordingly in Freiburg the belfry rests on the square of the tower according to the ground form given in the lower half of Fig. 1404, i.e., it is internally square and on the exterior is made the transition from the square to the closed angle turrets formed with equilateral triangles (Fig. 1403). The latter rise as accessible space to nearly the full height of the belfry, thus retaining of the square plan in the interior so far of value, and it terminates inside by the before mentioned angle vault supporting the diagonal sides of the octagon, Fig. 1405, which represents the interior of the belfry in diagonal view, makes this arrangement evident, which was already given in Fig. 96, but the posts supporting the ceiling of stone slabs above the ribs are not drawn.

Above the belfry is then found a high octagonal hall crowned by the tracery spire, opened by eight great arched windows on all sides divided by mullions, whose plan is represented by a b c in Fig. 1404.

At the height of the latter the angle turrets have only the purpose of loading the angle piers, and accordingly exist in t the well known tabernacle form, whose terminal finial rises above the base of the spire.

The effect of the additions like tabernacles is thus heightened, in that they project beyond the arched openings found in

the diagonal sides of the octagon. These are also properly to be regarded as the spires of thesetriangular angle turrets, whose closed sides are decorated by mullions and tracery, and form a very happy connection of the simple lower story of the tower and the rich and airy forms of the octagonal hall and of the spire. This combination is thereby closer, since the ground form of the belfry and thus the octagon with the four triangles adjoining the diagonal sides extend down also a short distance into the tower square, and ther first pass by washes into the full square, so that the buttresses of the latter with their caps extend to the sides of those tr angular walls, and with the wide projection that runs around on the base of the belfry, enhances the sharp impression of the separate stories by the balustrade supported by corbels, yet without disturbing in the least the intimate relation of all parts to each other.

If we now collect together the peculiarities distinguishing the Freiberg tower from the previously mentioned French examples we have the angle turrets enclosed by walls instead of being open, a tabernacle form crowning them instead of the simple spire, instead of the belfry directly covered by a spire on French towers is a hall placed thereon, and as an addition the passages at the base of the belfry and of the spire.

These passages manifestly originated in the purpose to open accessible interiors to the people, to afford them the opportunity of a distant outlook over the country, and thus to transfer to the tower the intervention of the church in life.

They replace in a more perfect way the usual terrace over the middle aisle on French churches that cannot be combined with t the plan of a single tower. But that the people took possession of the floor granted to them and then constantly enjoyed it, c can every one prove that seeks these places. Therefore we may not lack those parts of Germany above in the air, such as offered by the Freiberg and Strasburg minsters in their terraces, to which Goethe still drank golden Rhine wine; yet his relation to the Strasburg minster is not the last, which makes it of value to us.

Tabernacle forms instead of angle turrets.

The connection of the angle towers with the interior is wanting on the later German magnificent towers. The charm of those tabernacle forms, which only serve as crownings in Freiberg,

might well lead to elevating them as the chief object, i.e., to constructing the angle turrets more as angle piers that ever m more artistic combinations of figure shrines and finials, and thus finally forming mere show pieces, that rising from the base of the octagon as solid masses, only serve to load the angle p piers, but with all splendor missing what is found in Freiberg, namely the fulfilment of a purpose increasing with the whole.

On certain later works like the tower of S. Bartholemew in Frankfort, these tabernacle forms received a broader purpose, for they were characterized by little flying buttresses turned to the angle piers of the octagonal belfry and certainly as supports of the latter.

Continuation of the octagon downward.

As before noted, on the Freiburg tower the transition from the square to the octagon is already prepared in the story below t the belfry and corresponding to the church roof. A further advance consists in this, that the beginning of the transition is utilized as a motive for the treatment of the next to the last story for its full height, as on the towers of the cathedral of Cologne, on which the buttresses of the octagon of the tower extend down to the walls of the square to the cornice fixed by the height of the clearstory.

On certain smaller towers, like that of the Nicolai church in Frankfort and the chapel at Kidrich, the octagon of the tower extends itself down to the portal story. The transitions are l found above them on the first tower simply by washes, on the latter being effected by a tabernacle form adjoining the side of the octagon. That the carrying of the octagon deeper already occurs on Romanesque works was already mentioned on p. 571.

Placing the octagon diagonally.

The complete opening of the sides of the tower square by two windows as at Cologne and Ulm brings with it, that the angle f pier of the octagon comes to stand on the arch od a window. The height of this transition is found in Cologne above the second story, on other towers above the succeeding story. This arrangement brings into expression the homogeneousness of the division into separate heights. If the octagon of the tower is displaced so that two diagonals of it coincide with those of the square (Fig. 1407), then results the necessity, on account of the increased thrust of the four transition arches at the angles and

loaded by the piers, to annange some piers strengthened by buttresses at the middle of the sides of the sjuare, as in the lower half of Fig. 1407, or where those transition vaults strike the walls as in the upper half, while the proper angle piers of the sjuare are relieved and are recessed in a rather idle position. The bisection of the side of the tower square by the middle pier can thereby be made at any division in height, butfirst over the projecting portal as in Fig. 761, the middle pier standing on the crown of an arch.

This bisection may then also result from the arrangement of the plan, especially if the towers belong to doubled side aisles as on the cathedral of Cologne, and is only avoided on the cathedral of Paris by that peculiar arrangement of the lower vault of the tower described more fully on p. 313.

Development and crowning of the octagon of the tower.

On the octagon of the tower all sides are opened by windows, or only those parallel to those of the square. The latter being when the other four sides are occupied by adjacent angle turrets or other transitions.

The arched openings themselves are single or divided by mullions, according to dimensions. Mullions are here indeed substantially ornamental, where glazing is not concerned, but make more difficult the placing of the louvre boards and therefore are n wanting on most older French towers.

The angles of the octagon of the tower appear as simple edges or are strengthened by projecting little angle columns bonded with the masonry or by forms of piers.

These little angle columns may either have their capitals in the cornice terminating the octagon of the tower as in Fig. 1403, or afford a support for the gargoyles at the base of the spire, or if the latter are wanting, may directly receive the ribs of the spire as in Fig. 1390, or finally if a passage is arranged at the base of the spire, bear the pinnacles which rise to strengthen the balustrade. The angle piers as at Freiberg (Fig. 1404) may be formed according to two sides of the square or as ordinary choir buttresses, with their caps attached to the angles of the belfry, or also join those of the spire, or rising above the balustrade be crowned by simple or compound pinnacles, as in Freiberg (Fig. 1403) and Cologne. We however call attention to this, that in Freiberg the inner of the four

little pinnacles is omitted in order to avoid the reduction of the passage (d in Fig. 1404).

Stair towers.

Between those angle piers there extend the tracery gables on the said piers as on many others, that crown the arched openings and rising above the balustrades, which however differ in no essential respect from those occurring in other places. Only in Freiberg the tracery balustrades do not pass behind the tracery gables but terminate at them on both sides. This sixteen-fold crown formed by the tracery gables with the pinnacles offers a substitute for the eight little side turrets of the early French spire, yet we must say that it does not attain the grand effect of the latter, even if it already excels it in richness.

We have already mentioned on p 590 stair towers, which are enclosed by the angle turrets forming the transition to the octagon. These are opposed to the towers of Freiberg and Cologne, where is found a complete separation of both, when the stair towers are suited to their purpose and hence in entirely different form join the angle towers in their lower parts, but are f free from them in their height. Thereby the symmetry is certainly somewhat disturbed, since only one stair tower is needed, b but the picturesque effect is essentially increased.

On the later magnificent towers of Strasburg and Ulm on the contrary, entirely symmetrical designs are made possible, since each of the four angle towers becomes a stair tower. These stand entirely separate from the belfry, rise above the upper balustrade and are connected with its floor by bridges. On the Strasburg tower, whose construction up to the apex of the spire is determined in its character by the system of steps, evey this result is justified, this thoughtful execution, the almost modern design of three superfluous stairs, while in Ulm (according to the original drawing) the purpose of symmetrical execution at any cost still is certainly disturbing. The continuous cross bond that such stair towers receive by the steps, gives to them ar extraordinary stability and make possible the least thickness of the walls.

Yet we mention the perhaps unique plan of the stairs of the towers of Meissen, that are not arranged in a separate hall, but are found in the thickness of the wall, though in inclined straight flights along the sides of the square tower, these

being made visible by openings.

4. Smaller Turrets.

Little turrets above the western gable.

We have already given in Fig. 814 a an example of a little t turret, that is borne by buttresses projecting from the bable wall and is corbelled out from that. If the buttresses are wanting, the corbelling is naturally from the face of the gable wall and then must be stronger according to conditions. It is to be noted here, that on account of the corbelling, equilibrium at both sides must be approximately equal.

The ground form of such turrets can be the square or any preferred polygon, and indeed the small dimensions customary here make the hexagon particularly suitable.

The form of the corbelling is first determined by the section, and it may be in a radial direction by means of separate projecting and superposed courses, or be made by separate corbels covered by slabs or connected by arches. The first arrangement is less adapted to the square than to the polygonal form. The size of the loading further makes a steep direction of the corbelling preferable, which can be obtained by the profiles of the courses as also by separating the projecting courses by others bonded in the face of the wall.

The corbelling must always commence so deep, that from the attic floor is an access to the interior by means of a stair or a ladder, so that an opening can be made through the corbelling (Fig. 814 a) or above it.

The mode of treatment of such gable turrets is derived from that of the great towers with regard to the reduced dimensions and the changed construction.

Thus we have a belfry crowned by a spire and with open arches on all sides, under this being found a room with closed walls above the corbelling, which contains the bell cage. The angle piers of the belfry can be strengthened by buttresses.

On little chapels the gable turret sometimes shrinks to two side piers, which directly receive the axles of one or more bells. The piers are joined at top by an arch or are covered by a protecting roof.

Turrets above the triumphal arch.

Instead of gable turrets over the western facade, they sometimes appear above the gable rising above the apse. Finally

they sometimes rise from the roofs which then conceals the corbelling. In this case they are placed on the wall erected over the triumphal arch, like a rich turret at Clomar and one at Zwetl. Then the wall above the triumphal arch and beneath the turret can be opened into the attic; on the Maria church at Stargard it is opened to almost the width of the clearstory, so that the roof turret is borne by a great pointed arch, that is abutted entirely over the side aisles by bold abutting walls.

As the finest example is to be regarded the truuet mentioned on the church of S. Katrina at Colmar, that reproduces in small dimensions the design of Freiberg tower with all its magnificence, angle pinnacles, tracery gables over arched openings, tracery balustrades and perforated stone spire.

The smaller stair towers and side turrets also occurring elsewhere on churches exhibit forms like the principal towers, even if also mostly in simplified form. They frequently pass into t the form of pinnacles (See Finial).

5. Stone spires of towers.

Simple spires of cut stone.

Origin and use of stone spires.

Massive and also serving as a roof to cover the interior, they extend back in southern countries without wood into the earliest period of civilization. In Byzantine art are frequently found very commonly domical or conical and pyramidal stone roofs. The external and internal surfaces may have like forms, or may differ from each other as in Fig. 1408, which internally is a dome and externally shows a pyramid or a cone. Such domes or spires can be made entirely or partly of concrete, rubble, or consist of regular ashlars or of bricks. The regular stones appear externally, while the irregular masonry is either made even by proper mortar,or better has a protecting covering of tiles, stone slabs or even of metal (lead or copper). Those old buildings in the Caucasus are frequently animated by conical or pyramidal massive tower roofs of moderate inclination, that are covered by great slabs of limestone, on whose joints are cover stones as on Greek or Roman roofs.

Domical spires.

In northern countries somple thin stone roofs over closed rooms are unsuitable on account of the sweating of the inner surface in low external temperatures, but this is not in the way of their

use with the arrangement of isolating interspaces, if they a are well built otherwise; they are entirely suitable over open rooms beneath like the towers, where they still have over other roofs the advantage of power of monumental treatment, greater duration and of safety from fire. Therefore stone spires predominated in all mediaeval times and will also be again erected now, since they are worthy, not dearer but even cheaper than wooden spires. Their walls may be thin and their trust is quite unimportant with sufficient steepness. Since not only domes but also conical roofs and thereby polygonal pyramids are statically favorable forms of vaults (p. 56 and 604 later), their treatment permits great freedom and even complex corbellings, as on the towers of S. Paul at Worms,(Fig. 1409), but make no great difficulties. The towers of S. Leonard in Frankfort have domical roofs and a peculiar spire between a dome, cone and pyramid, below which is also found a transition from the square to the octagon worthy of consideration, as shown by the foundation church at Treysa in Hesse (Fig. 1410), that has come to us only in ruins.

For about 2/3 of its height,the spire is in the form of a steep pointed arch, and from thence with a scarcely noticeable b break it is made rectilinear. There are lost at the same height the angles of the octagon, which accordingly pass into the circle, as well as its construction is there transformed from that of the octagonal dome to that of a cone with horizontal rings. The heavy effect of the spire mentioned is nowise based on the line of a pointed arch, but results from the placing of the angles above the front face of the point of the gable. All from its low proportions. This curved outline is even found retained on certain Early Gothic great pinnacles of Freiberg minster, in a sense as an entasis, and likewise for its effect as a form as well as for structural reasons is preferable to the concave contours of spires occurring on certain Late Gothic towers.

Pyramidal stone spires.

Generally in the Gothic period disappear the domical spires, and the octagonal pyramid ever predominates, but besides it are found occasionally the square or hexagonal pyramid and the cone; more on the form of the spire and this transition to it was already given in the preceding Chapter, but on the thickness of the wall etc., see the next Chapter.

For reasons of stability the spire rests on the inner edge of the wall (Figs. 1406, 1411), whereby the wall is also corbelled out inside somewhat. The projection of the wall is occupied by a passage or by an inclined covering (Figs. 1355, 1355 a). But it is equally possible to continue the external surface of the spire over the wall, thus cutting off the part c e d at the right in Fig. 1413. Since the centre of gravity of this part of the wall lies toward the outside, it adds little to the stability, and particularly for relatively thick walls may be omitted or even be objectionable. The remaining part a b of the wall at the left in Fig. 1413 must always be constructed as well bonded masonry, vertical on the inside or corbelled out if possible and of not too light material.

Direction of the bed joints.

Cut stone spires are built of horizontal rings or courses of uniform height, and thus can be arranged according to the usual dimensions of the stone. The bed joints may be horizontal or be perpendicular to the surface of the spire (Figs. 1412, 1412 a), the transmission of the pressure not being influenced thereby. Beds perpendicular to the inclination of the spire (Fig. 1412 a) have the advantage, that the stones retain their rectangular edges, and on the contrary have the defect that with bad mortar the rain can penetrate into the inclined beds, and further the joints at the angles are less simple. Horizontal beds avoid this defect and make it possible for a better transition to the stone courses of the tower wall, when the surface of the spire extends over them (Fig. 1413). The only objection to horizontal beds is the oblique shape of the stones, but which aside from the difficult erection of steep surfaces requires no consideration. For very flat spires both kinds of beds are unfavorable, one for t too great inclination and the other for the acute angles of the stones, and both for the danger of sliding inside or outside. Reducing the inclination generally increases the difficulties in every point of view, while the erection of slender spires is scarcely to be distinguished from that of an ordinary wall.

Generally horizontal beds will be preferred for cut stone, a and men have sought to avoid the acute angles of the stones in various ways. The simplest means is a stepped setting of the stones (Fig. 1414), the towers at Ver and Poitiers (Dehio and von Bezold, Plates 277, 278) present examples of this. For the

purpose of removing water more rapidly by washes on the projecting ring surfaces, appears to have required the animated motive of scales recessed upward, as on various towers at Periguex, y Massac, Poitiers (Dehio & von Bezold, pls. 249, 277). Better is the purpose served by a slope of the surface of the ring (Fig. 1415), whether flat as a b or steeper as a c. So long as a little vertical part c d remains the acute angle is avoided, and further is obtained the advantage that the joint lies in a vertical instead of an inclined surface. As shown by Fig. 1415 a the advantages of this stepped inclination predominate over those of the simple one particularly for flat inclinations, and in fact it is employed in southern France for roofs, that only have an inclination of between 30° and 45°. For steep spires it is only of value, when the small steps are not vertical in space, but are perpendicular to the wash (Fig. 1416). The beds can then be more effectively protected against the penetration of water by arrangements like Figs. 1417 and 1417a.. On steep German spires men have mostly been satisfied by a smooth external surface. On many French towers the projections (Fig. 1418) are utilized for carving scale work, whose angular or rounded points are turned downward (Fig. 1418 .). The scale work covers the entire s surface as on the north tower of S. Denis, or it alternates with plain bands as on S. Etienne and S. Pierre at Caen. The hips there receive projecting strengthening ribs with or without crockets. The upper solid cap of the spire that extends downward (mostly 2 to 4 m) can be characterized externally by a special treatment, for example takink the form of a colossal pinnacle. (Fig. 1419).

Stone crowning.

The most common stone crowning of the apex of the spire is a round, lenticular or richly profiled knob, that directly rests on the apex of the ribs or is raised by a stem; on Romanesque towers (like Worms) it often has a form and approaches the intersection of a sphere and cube. There frequently rises above t the knob a stone cross, also forms of animals, men or angels sometimes occur. The knob also takes the form of a cone or a bud, for which develops by the extension of leaves the cross flower with four, rarely with six or eight arms. Otherwise is applicable to the crownings what was said for finials.

Projection of crownings.

The projection of the crowning was not excessive in the better time, since it otherwise would easily injure the aspiring character of the spire and weaken the impression of the whole. As its construction depends on the dimensions of the ashlars, it is very natural for great towers to have relatively small crowns. First in the late time as for pinnacles the projection is placed more in a fixed relation to the spire, and thus became colossal crossflowers more than 3 m wide, only executed with great labor, as shown by the Liebfrauen church at Esslingen. Recently faults are frequently committed in crossings and in statues placed high, since men take too much account of the probable foreshortening, but a skilled eye is little deceived by foreshortening, unless with it is connected the concealment of a larger portion, so t that detached art works also have a good effect from a distant point, as being in almost geometrical elevation.

Security against overthrow.

Crownings are easily overturned by wind (for safety on account of vibrations, men reckon at least 200 to 250 kil wind wind pressure per square m of the greatest area of cross section). The upper stones must therefore have sufficient weight and before all a suitable base. For the crowning of Fig. 1420 would the bed be placed at least down at f f, but if necessary even at the middle of the knob e e. But both would only be sufficient with very great dimensions (here at least 60 to 90 cm width of bed), and for smaller dimensions the first bed f f must lie even much lower.

It would easily be overlooked that the stability of a body a against wind depends not alone on its form and weight, but also on its absolute dimensions. (The overturning moment increases only in cubic, but that of stability in biquadric proportion to the linear dimensions). While a stone cube with a side of 5 cm with a specific gravity of 2.4 may be overturned by a wind pressure of 120 kil per square m, a stone cube with a side of 50 cm would require 1200 kil per sq. m for this. Likewise with 200 kil wind pressure a prism of the same stone 100 × 100 cm must have 12 times that height (12 m), for a base 20 × 20 cm it could have scarcely 2 1/2 times that height (48 cm). In the same manner is it explained, that the wind may raise specifically heavy bodies in the form of grains or dust in the air.

If the crowning is too light, then ashlars are drilled verti-

vertically and an oron bar (far better a bar or tube of copper or brass, the latter as sheath for the iron bar) is passed through, and is held beneath the solid masonry apex for this purpose by a key (Fig. 1421 at b), the cotter, a plate or a weight. Recently these rods are generally combined with a lightning rod, which runs down outside or inside the spire. The solid masonry of the apex down to the internal width of 25 to 50 cm or more is usually advisable for practical and statical reasons, but much material is not necessary for this.

Iron crownings.

When the iron bar is once used, it is next to allow it to extend above the knob of stone or wrought metal, forming a cross, weathervane, star or other iron crowning. For example a cross may have a form according to Fig. 1421 by a projecting riveted cross bar with varied curved stiffening bars c placed in the four angles. It is made tight above the knob by a wrought projection a and also finally by also a lead flashing. Above the knob is twisted the square bar in the mode of Fig. 1421 a, end thereby the resistance to bending is made rather uniform in all directions. For larger crosses the bar requires stiffening by 2 or 4 braces at bottom (Fig. 1422), which rest on the knob or better extend down on it about as in Fig. 1423. (After Viollet-le-Duc, Vol. IV, p.428). Further on iron crownings that already occurred in a very early time, see on wooden towers.

Perforated spires of towers, passages, enrichment of angles, etc

The spire may remain entirely smooth, or it may have strengthening mouldings on the angles and also at the middle of the sides (Chartres, Vendome), and besides be enriched by scale work on the surfaces.

Dormers and slits.

But an effective animation is received by the surfaces of the spire by single or numerous perforations, that are desirable up near the apex on account of the escape of the air, but which a also find places elsewhere at differenh heights already on the towers of the transition style are added dormers or openings. an example of this kind is presented by the Liebfrauen church at Worms in Figs. 1424 and 1424 a. On French towers these openings are made very slender. also they occur without caps as long rectangular slits in the surfaces of the spires (S. Denis, Soissons, Rheims). They are very easily made, but at too great a heigh

are not strictly favorable, since with very thin walls they break too much in important ring stresses.

Polyfoils.

Richer and more animated appear openings of central form, that are cut out of an inserted large stone slab, or in the coursed masonry. They may lie at greater distances above each other as on S. Etienne at Caen, where they perforate the surface of the spire ebtween the scale bands in dimensions decreasing upward as sexfoil, cinqfoil, quatrefoil, and finally at top as three ever diminishing trefoils. On the towers of Seez they lie as cinqfoils close above each other and make room above for slender silts. Generally may the polyfoils and slits are connected alternately with rich surface ornaments.

Forms of tracery.

All forms of tracery, both windows divided by mullions (on the crossing tower at Lichfield in England even with rich tracery gables over them,) as well as combined polyfoils and roses could develop here, so that thereby they approach each other more closely and finally extend over the entire surface, their original and extremely airy and rich development of the spire, that chiefly occurs in the provinces of the former German empire and indeed finds its most perfect example on the tower of Freiberg minst

As other rich examples may be mentioned the minster of Strasburg, Liebfrauen church at Esslingen, whose spire was charmingly enriched by a passage near the apex, church of Thorn, the little tower on the cathedral of Meissen, the minster at Basle, cathedral at Burgos, the restored spire of the cathedral of S. Stephen at Vienna, and the particularly rich spires at Cologne, Regensburg and Ulm, that only came down to us in drawings, which have remained till our time for completion, and in part still so continue.

There is adready much dispute concerning the contradiction in the design of a perforated roof. If already it is not a lie, t that we have here to do with a developed structure rather than with a form developed from construction on account of its formal effect, certainly in a more perfect way, then the current applications are unfounded, and the principle that lies at the basis is indeed carried to extremity, but is nowise false. For first as the Freiberg tower shows, the perforated spire is not at all a roof, but it forms the upper hall above the belfry only enclosed

by eight slender piers connected by arches and thus open on all sides, whose stone floor is the actual roof, from which the rainwater is conducted by gargoyles.

If they in Freiberg that hall was never intended for a belfry, yet a use of it in that sense would easily be possible, when t the bell cage and the bells therein contained were protected by a roof above with louvre boards covered by lead fixed around it, as the case in the southern tower of the cathedral of Paris, (Viollet-le-Duc, Vol. II, p. 192), in the latter where the rainwater is freely admitted through the 8 great arched openings. Therefore since closing the arched openings with that covering of the bell cage became superfluous, the same case occurs in r regard to the roof, and thus a perforation of it must be allowable.

Accordingly the situation of the matter is about as follows. So far as nothing is found in the interior of the tower, which can be injured by rain, it is fully justified to allow it free entrance. But that in Freiberg nothing is injured must be proved by the duration of nearly half a thousand years. Just as well have the towers of Notre Dame endured with a perforated spire.

Therefore the design of such even represents the development of the highest magnificence, that also still has its rights. At least no one will easily doubt this, that has seen the crown of the Breisgau. But just as this splendor is the highest with regard to the date of erection as the last on the building, so t should it also be the last, and it is generally to be thought, that it should only be striven for when nothing else must be lacking. The crown alone ornaments the purple mantle, over which the ordinary covering would be puerile.

The effect of the magnificence peculiar to the perforated stone spire is entirely lost in its modern imitations in cast iron. It is a confusion of idea to compel the latter material to take a form entirely foreign to it. Every attempt is in reality nothing else, than if one were to require a cast iron lamp post arm to have the form and strength of a corbel. Indeed no objection could be raised to a cast iron spire in itself, whose forms were even developed from the nature of the material, but so far such attempts are lamentable failures, and especially as shown by the spire on the central tower of the cathedral in Rouen.

The construction of the perforated stone spire differs according to the dimensions.

Construction of the surfaces.

In smaller dimensions, which permit composing the side of the octagon of a single slab in width, these slabs are so placed above each other, that the butt joints alternate at the angles (f in Figs. 1425 and 1425 a). Thereby is determined the width of the plain surfaces accompanying the angles of the spire by the need of leaving to the slab the necessary thickness at the joint f.

The simplest case would then be as shown by Fig. 1425, to form quadrangular panels and arrange the tracery in them, so that the height of each panel should about equal its average breadth, or to give all panels approximately so that the lowest panel is n nearly square.

Greater freedom in the treatment of the tracery results from abandoning the quadrangular form of slab and the allowance of bed joints which directly cut the bars of the tracery at right angles (Fig. 1426). According to the same system in larger dimensions the separate sides of the octagon may be composed of several pieces in width, alwans with the condition that the joints cut the bars of the tracery at right angles.

But there as in a horizontal arch occurs a pressure of the s separate pieces toward the angle, thereby producing in the latter the thrust directed outward, they weaken.

A resistance to the latter results from the weight and the stiffness of the projecting ribs, either at one or both sides, whose construction is nearly analogous to that of the ribs; i.e., the separate pieces of them rest on each other and receive the perforated slabs of the walls of the spire, as the vault ribs at the masonry of the compartments. Therefore in plan they receive in the simplest case about the shape given in Fig. 1427.

Just as the ribs of the spire prevent by their dimensions the deflection of the walls, so do the walls prevent any bending of the ribs toward each other. To increase this resistance and generally for a stronger connection in larger dimensions, the separate tracery divisions must pe divided at certain heights by h horizontal long slabs or stone beams, which lie as ties between the ribs and form firm bands around it.

Fig. 1428 represents the lower part of an octagonal side of the Freiberg spire, where the ribs proper do not project outside, while the piece v on which rest the crockets has little structura

importance and those ribs are set with only one tongue and further are connected by single iron pins.

For the height of each division the ribs consist of two or more stones set on end and on each other, between which are inserted the separate tracery slabs, so that the plan at the height concerned shows the arrangement of the joint in Fig. 1404. A further connection with the tracery slab is then made by a header a, at the height of which falls the joint marked f. On the headers a are then laid the long pieces b, whose butt joints sometimes are at the middle and sometimes in doubled number at both sides about as at x, are again connected by the piece d lying thereon, so that a bond is formed at each division of the tracery in height, whose permanence can be ensured by a connection with tongue and groove in the bed joint, as shown by the cross section in Fig. 1428 a, or completely by dowels.

In the succeeding divisions of the Freiberg spire the headers a are omitted, and the end joints f extend through to the horizontal band, which then again are connected with the ribs by the pieces b and d as headers.

The peculiar system of this construction is not clearly expressed in the Freiberg spire, since each horizontal band is no more indicated by projections than the ribs.

From the original drawings of the towers at Cologne, there appears to result a consistent construction of the ribs and bands, in so far that both parts are indicated by bold members, and thus form a framework, in which are inserted the slabs perforated in tracery. By this may then the permanence of the band either be produced, the two courses lying over each other being alternately end joints, or with this alternation of joints is produced by its connection with the tracery slabs lying above and beneath it.

Development of the ribs.

The ribs, which have such an essential place in the construction of the perforated stone spire, are also found on the unperforated spires in order to strengthen the angle connections and chiefly the angles, and they are then either and indeed best formed on the ashlars of the separate courses, thus requiring a greater thickness of them, or in rarer cases, like the piece r on the Freiberg spire (Fig. 1428), they are attached to the hip and fastened there by separate headers.

From the headers could extend the crockets, which would only require a greater length, if they were not originally found at other places, like the pinnacles and apexes of gables, so that the transfer of them to the spire for their decorative effect is to be assumed as determined. On the Freiberg spire then are made in the same pieces with these angles as already mentioned above, and later were fastende to the spire by iron clamps. Yet this construction is only to be regarded as a help in need, the cutting them in the ashlars of the courses or a deeper insertion in the angle of the spire is likewise to be preferred in every case. To the size and spacing of the crockets applies what was said concerning pinnalces, i.e., neither can be assumed a relation of the number nor size to the dimensions of the spire. Before all is required a clear and easily recognizable form, so that already on this ground the older and volute forms deserve preference. On one of the original sketches of the tower of the Strasburg minster, they are replaced by an arch with cusp, which also occurs on the tracery gables.

Passages and intermediate stories.

The dormers opened in the spire (Fig. 1424) utilize the wall of the spire to support the vertical front and side walls; such a moderate load reduces the stability very little. Never injurious and often useful to stiffen the bond appear those passages placed on projecting cornices with perforated balustrades (Fig. 1430), as they are simply found forming four gables above the base of the spire on the Marburg towers. On certain works of the later time are then frequently repeated, most extensively on the original drawing of a tower of the cathedral of Regensburg, where then above the angles of the spire they have piers crowned by pinnacles, that below the bases of the pinnacles are connected with the ribs of the spire by flying buttresses, that again join below the corbelling of the nearest balustrade above them. In such a form they dominate the entire structure and nearly neutralize the effect of the ascending line of the spire.

From the same structural principle results the design of an intermediate story opened by windows at a proper height of the spire, whereby it is separated into two divisions, about as in Fig. 1429. The thickness of the vertical walls of the intermediate portion can be greater than that of the lower wall of the spire, and must suffice to resist the thrust of the upper part.

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Below the vertical wall results no difficulty, since here the pressure in the bond equilibrates all (p. 614). The thickness of the walls of the two portions may differ.

Stairs and pinnacles on the angles.

The grandest and most spirited application made of the supporting power of the spire is shown by the north tower of Strasburg minster. The construction of this is so well known an is represented so masterly by Viollet-le-Duc (Dictionary, Vol. V, p. 439), that I shall here limit myself to a bried description of the system.

For at the height of the base (Fig. 1431) a stair tower projects from four of the six angles of the spire, whose newel stands at the angle a, and which only contains the steps from c to d. From the first is then developed a second stair tower, whose piers e and f stand on those of the lower part of the tower, while g and h rest on the walls of the tower, the front corner pier being placed on the newel a. This second stair tower contains the steps from d to i, and supports in the same manner a succeeding one, so that the course of the steps follows the dotted spiral in Fig. 1431. There are now developed on each angle six of such stair towers over each other, by which one reaches the height of a landing from which a stair winding around the centre of the spire reaches a middle turret crowning the spire. Between those eight stair towers the walls of the spire are richly decorated by tracery.

Such loading of the rib of the spire is often very favorable statically (p. 609), and in another form is expressed by the change of the crockets into pinnacles, whose supports are cut on the ashlars of the spire, while the body and finial are made of separate pieces. An example is shown by a stair tower on the south side of Strasburg minster. Yet this produces a peculiar spiny appearance.

Brick spires.

The erection of sipres in brickwork follows substantially the same principles and only requires simpler design and details, and there the bed joints may like cut stone spires be normal to the inclination of be horizontal. Yet horizontad beds either demand bricks of special shape or a stepped surface. Still on account of the height and the steep inclination, the resulting small width of the steps is scarcely perceptible from below.

Ornamentation of the surface results most simply and suitably by a pattern made of bricks of different colors.

As in stone spires the termination will be of solid masonry, and the crowning will either be of cut stone set there, an ornament of terra cotta, or finally only by a lead cap covering t the base of the iron rod and the joints, which is then capable of any richer form.

In a manner entirely similar to that of stone spires, there may also be formed here openings of different shapes, first being simple slits, then those openings formed like dormers about as in Fig. 1432, yet the latter only with horizontal joints. The position of joints normal to the inclination makes possible certain circular or polygonal shapes, thus more openings like tracery (Fig. 1432 below), that are naturally often enlarged a and occupy large surfaces. A complete perforation of the brick spire like one of stone with special shaped tracery parts however does not exceed the limits of possibility, but still is not advisable.

Generally the durability of good brick materials is also subject to certain limitations in a place exposed to weather in s such a high degree. One must avoid too ornamental details, also with the use of a thickness of only half a brick walls for the smaller spires or for the upper part of larger towers, men must be careful unless the best material (best glazed hard clinkers) and reliable waterproof mortar (tolerably rich cement) are used. Good glazing can substantially increase the durabilitn of bricks, for which proof is given by the so-called blue tower at Lübeck dating from about the 15 th century, whose walls are constructed with alternating red and black glazed bricks, the former being corroded for several inches in depth, while the original surfaces remain on the latter. Glazing badly crumbled and with many hair cracks may be more injurious than useful. As a defective substitute for good glazing or other bricks resisting weather may serve a coating of the best possible mortar, which also occurs on stone spires of rubble masonry, and is found on the tower at Treysa represented in Fig. 1410 and the Eschenheimer tower at Frankfort. The mortar must be replaced after injury by weather, since otherwise the softer bricks beneath it will be attacked at injured places, and in this consists the defect of the coating, which otherwise as a coating is inferior in style to

the appearance of the proper material, but is not to be rejected so long as it does not imitate a different material.

For the construction of the angles are required bricks of special shapes already on account of the obtuse angle, which can then be furnished with a projecting member. But this contributes but little to the very desirable strengthening of the hips with the thin walls of the spire, and therefore is better a bonded projection in bonded masonry according to Fig. 1433. A strong bond at the hips and the internal strengthening or at least an internal filling of the angle is very advantageous. For richer ornamentation the ribs or angles without ribs can be combined with crockets of terra cotta or better of stone.(Fig. 1434).

6. Stresses, thickness of walls required and thrusts of masonry roofs.

Conical spires.

If it be desired to support against each other two thin walls in mortar unable to resist tension as in Fig. 1435, then the m masonry will fall inward after carrying the uppor portion up h high. If it could only be made durable so that the upper angle can be made solid, so that the line of support can find its place within it (Fig. 1436), or such a great load be laid on it, that a correspondingly steep line of support can be formed therein (Fig. 1437).

It is otherwise for a roof of conical form, here also the parts of the struts that would fall in hinder each other, when they support themselves against each other in the form of a ring (Fig. 1438). The masses pressing inward produce a ring compression, which is the greater, the flatter the cone.

Ring compression and longitudinal compression.

Therefore in the cone are to be distinguished two kinds of compression in the covering surface-- 1, a ring compression t that is strongest below and gradually diminishes upward till it becomes 0 at the apex; 2, an oblique compression directed downward, that by the effect of the weight of the stones is transmitted from stone to stone, and thereby also gradually increases from above downward; it may be termed longitudinal compression. For a cone under the influence of its own weight it may be assumed with sufficient accuracy, that the longiludinal compression in the sides passes down at the middle of the thickness of the wall, for if it would take a different direction, then the

ring compression acts to equilibrate it, an advantage that the conical vault has in common with all domes compressed in the direction of a ring (p. 55).

Load on the abutment and thrust on it.

The compression of the conical spire on the walls becomes very simple under this assumption. It is just the longitudianl compression acting in the inclination of the covering around the entire cone. To find it, a narrow triangle is taken from the apex to the base of the covering (Fig. 1439). At its centre of gravity O is applied its computed weight G, and from O is laid off the weight G vertically, and from O is drawn the line S with t the inclination of the cone, then from A is drawn a horizontal H, and the compression S sought is found in direction and magnitude. Equally simple is it found by the equation, $S = \frac{G}{\sin a}$. (Here a is the angle of inclination of the cone, so that sin a = height divided by length of slope).

Instead of this compression S acting obliquely on the abutment, it is more convenient to calculate with its components (see bottom of the Fig.). The vertical component loads the abutment and equals the weight G of the corresponding portion of the cone; the horizontal component H forms the thrust against the abutment, and is found by the parellelogram of forces (at bottom of drawing), or yet more simply from the already mentioned triangle of forces O A B, whose base represents its magnitude. Instead of drawing it, this may be calculated from the equation:--

$$H = G \cot a, \text{ (or } H = \frac{G\,r}{h}\text{)}.$$

The thrust H acts radially at the entire circumference' if in the preceding equation for G is substituted the weight of the entire cone, then is obtained the sum of all thrusts acting at the circumference. If it be desired to obtain the thrust for a smaller portion, for example $\frac{1}{12}$ of the circumference, then this total thrust is divided by 12, or there is substituted in the preceding formula only 1/12 of the weight of the cone. Also for such small portions of the circumference (Fig. 1440) the thrusts still diverge somewhat, so that their resultant will be somewhat smaller than their sum (in proportion to the length of the chord to the length of the arc); but the difference is but small, amounting for 1/12 the circumference to about 1 1/2 per cent, for 1/6 circumference to about 5 per cent, for 1/4 to about 10 per cent, for 1/3 to about 17 1/2, and for 1/2 to 36 1/2 per cent.

The computed thrusts can thus be reduced in this proportion, if the correspondingly large portions of the wall can be regarded as sufficiently connected together. For a square tower as a rule can be taken 1/4 the perimeter in consideration (indeed with the angle) for an octagonal tower with round spire correspondingly 1/8, and for circular walls a piece of the wall between the larger window openings, or also a linear m of the perimeter, whereby the calculation is indeed abundantly safe. Otherwise the calculation of the abutment is exactly the same as for vaults (p.140).

Thrusts for different heights of the spire.

For equally heavy spires of different heights the thrust is about in inverse ration to the heights, as for example if the height be to the bottom width as 4 to 1, the thrust is 1/8 of the weight; for a height of 3 to 1, the thrust is 1/6 of the weight; for 2 to 1, it is 1/4, but for 1 to 1, it is 1/2 the weight, for half the height (inclination of 45°) the thrust is equal to the weight.

Otherwise the proportion of spires of equal weight be not compared, but those of equal thickness of walls, whereby the low spires weigh less than high ones, so that almost exactly the same thrust occurs for spires of sixfold, fourfold or double heights, first if they are yet lower, the thrust notably increases (see last column of Table on p. 607).

From this may one conclude, that on account of economy of material it would be preferable to make spires flatter, but this is not so, for just the greater weight of the high spire that rests on the inner edge, and thus on a very favorable place on the resisting wall, lends to it a greater stability. A comparison of the forces acting of the abutment in Figs. 1441 and 1441 a best represents this. Moreover tall spires are more easily erected, entirely aside from their more preferable effect architectura[l].

What is said here on conical roof almost exactly applies also to the thrust of pyramidal spires (see below).

Neutralizing the thrust by tension rings.

The thrust of the cone may be received by a tension ring instead of the stability of the wall, where a tension $Z = \frac{g\ r^2}{2 \sin a}$, or $Z = \frac{G \cot a}{2 \cdot \pi}$, prevails. G is the total weight of the wall, g is the weight of 1 sq. m of the surface of the covering, a is the angle of inclination, and r is the radius of the base.

Let there be obtained the magnitude of the thrust and of the

tension in a ring at the base, for a conical spire of brick masonry 25 cm thick and weighing 1800 kil per cu. m, with 6.0 m inside and therefore 6.5 m outside diameter, with 3 1/2 fold h height, hence 21 m inside and 22.75 m outside.

The weight is by subtraction of the hollow from the solid volume of the cone, and this amounts to; $G = \frac{1}{4} \times 6.5^2 \pi \times \frac{1}{3} \times 22.75 - \frac{1}{4} \times 6^2 \times \pi \times \frac{1}{3} \times 21) 1800 = 97,000$ kil. The total thrust = $H = G \cot a = 97,000 \times \frac{1}{7} = 14,000$ kil in round numbers. Since the circumference amounts to about 20 m, there is 700 kil thrust per linear m. The tension in the ring $= Z = \frac{G \cot a}{2\pi} = \frac{14,000}{2 \times 3.14} =$ 2,200 kil in round numbers. But this is a very small ring tinsdon, that may already be received by an iron ring of 3 sq. cm in cross section. Instead of it this small tension might pe neutralized by a circle of stone slabs or ashlars interlocked or clamped together at the lower part of the spire or upper part of the wall, and also the simple indenting and resistance of the masonry to tension will mostly suffice for it. If the masonry has a tensile resistance of only 1/2 kil per sq. cm, 1/2 sq. m. cross section of the wall ring, thus an enclosing wall of a few courses 2 or 3 bricks thick suffices to neutralize the entire thrust of the spire. But since a greater height of the wall may have an effect, the tensile stress almost disappears. Thus when one counts on a certain and even so small tensile resistance of the masonry, that certainly on account of any vertical cracks in unequal settlement has a certain consideration, then the effect of thrust of steep tower spires on walls need not be considered at all.

Calculation of longitudinal and ring stresses.

To compute the longitudinal stresses in the cone at any point, one conceives a horizontal plane cutting across the cone, and employs the formula already given:- $S = \frac{G}{\sin a}$, where G = weight of the entire upper part of the cone cut off, or may represent a triangle of this, while S correspondingly denotes the longitudinal compression at the entire circumference or at the base of the triangle considered.

The ring stress is obtained by the formula:- $U = \frac{g \cot a}{2\pi}$.

If one conceives that a ring is cut from the cone by two parallel horizontal planes, and its weight is computed, which is introduced as g in this formula, this gives the ring stress occurring in the ring cut out. If the sum of all ring stresses a

acting from top to bottom is to be obtained, this is only the entire weight G of the cone, that is to be substituted for g; t then is obtained exactly the same value that occurs below as tensile stress in a tension ring to neutralize the thrust.

For cones of uniform weight of the covering (q for 1 sq. m area), the longitudinal compression and ring tension as well as the thrust are also found by the formulas:-

$$s = \frac{q}{2h}(r^2 + h^2); \quad u = \frac{q r^2}{h}; \quad b = \frac{q r}{2 \sin a}.$$

Here s = longitudinal compression per m of circumference, u = ring stress per m length of covering in vertical section, and b = thrust per m of circumference. Then r and h are radius and height of the cone from the point of the covering considered. It is to be noted, that cones with equal thickness of wall is not synonomous with cones of equal weight of wall, but that the difference is small, if all dimensions are referred to a m mathematical conical surface lying in the middle thickness of the wall. The preceding formula makes possible a comparison of the longitudinal and ring stresses, which are equally great at each point for a cone of 45° inclination, and otherwise increase in proportion to the height. For flatter cones the ring stress exceeds the longitudinal compression, but coversely for steeper cones the ring stress is much the smaller. The succeding Table gives the relation of longitudinal and ring stresses for different inclinations.

Stresses in conical roofs of masonry.

(See Table on p. 607).

Example. A great tower spire is 12 m wide (r = 6 m) and 48 m high, of cut stone weighing 2400 kil per cu. m, for a wall 40 cm thick has a weight of q = 2400 × 0.40 = 960 kil per sq. m of surface, and thus according to the Table exerts at base a longitudinal compression per m of circumference of 4 1/16 × 960 × 6 = 23,400 kil. Hence 1 sq.cm would be stressed $\frac{23400}{4000}$ = about 6 kil. Conversely, the ring stress at the base would be only = $\frac{1}{8}$ × 960 × 6 = 720 kil per lin. m of inclined surface, thus per sq. cm it only is $\frac{720}{4000}$ = 0.18 kil stress. The same stresses in both directions would also result for greater or lesser thickness of the wall.

Required thickness of wall of spire.

Since the stress in the material is independent of the thick-

thickness of the wall, one would then be able to build a cone loaded only by its own weight as thin as desired. By unforeseen oblique loads, but especially by the wind pressure, that may m materially and substantialln displace the stresses (chiefly in the direction of a ring, which prescribes certain limits. Under the effect of wind, the ring stresses no longer retain the accurately course, but at the windward side and opposite this on the external surface and on intermediate points are moved nearer the internal surface, whereby greater angle pressure as well as tensile stresses may be produced, indeed most easily on spires with very small ring compression (slender spires and domical curved spires are opposed to the wind pressure rather at a disadvantage). When the masonry is only rather more secure by strength of mortar or by indenting, any danger from wind almost entirely disappears. In general may one assume, that a thickness of the wall of from 1/24 to 1/30 of the width for light material and of 1/30 to 1/36 of the width for heavy and strong material suffices, but that one can go yet farther for particularly good construction, especially if at certain distances in height are built internally projecting and strengthening rings.

The thickness of the wall can be made uniform up to the apex or be diminished upward. Brick towers can be made 1/2 brick thick for a lower diameter of 3 or 4 m up to 1 brick for 7 diameter. If the spire must be less than 1 brick thick, then it is most advisable to carry this thickness to the apex, because the lesser thickness in the upper part reduces the weight little, but therefore requires more careful construction. For somewhat greater widths the change to 1 1/2 bricks may be by internal projections of rings and ribs. The conical spires of brick on mediaeval towers mostly have a thickness of 1 brick.

Overthrow by wind.

The danger of the overthrow of masonry spires by wind is not great; it occurs with 200 kil wind pressure per sq. m of the full cross section for brick towers 1/2 brick thick, or correspondingly heavy towers of cut stone with 5 to 6 fold height, f for spires 1 brick thick the danger of overthrow no longer comes into consideration. On the location of the kern of the compression and of angular compression by wind, see farther below (p.627).

Circular compression.

The stability of the spire is best ensured, if the thickness

of its walls be made so great, that a circle can be described in the ground plan, whereby this ring-shaped transfer of the compression is,made possible as in the cone. Therefore for the octagon a thickness of the walls of at least 1/24 of the clear width is necessary, but it is better to take 1/20, so that the circle may remain at a distance from the angles. Most easily t the circle cuts inside at the angles a, and therefore for other reasons an internal strengthening b, c or d is very advantageous since it makes possible a ring-shaped transmission of the compression with walls of 1/24 or even 1/30 of the clear width.

Polygonal compression.

If the walls are so thin that a circle can no longer be drawn within them, durability is not thereby excluded, for segmental arched lines of support can be drawn within the sides (Fig. 1443 which intersect at the angles in a point F, there producing a resultant E directed outward. While thus the masonry of the sides presses inward by its gravity, the angles of the spire seek to press outward. The latter can be equilibrated by sufficient weight Q of the hips or ribs, that presses inward with a force = Q cot a (see further below under wind pressure). If the weight of the hip including the strips of masonry connected therewith at both sides does not suffice for this counter pressure.

Stresses at top and bottom.

There finally remains also the possibility, that the hatched portion C D in Fig. 1444 is thereby preserved from falling, that it acts like a straight ascending arch, which at the bottom C and the upper point D naturally produce great end pressures (reaction compressions). It is therefore a condition, that the upper part of the spire at a greater height downward can be considered as a firmly connected loading body. Farther below the shorter slips E F (Fig. 1444) may again act in the same manner.

Since the different possibilities of action reciprocally increase each other, the octagonal spire appears as a statically favorable form, so that it can be constructed in approximately is small thickness as the cone. Even thickness of the walls under 1/24 or that of the strengthening angles under 1/30, aside from wind pressure may still be permanent, particularly of a very small tensile resistance of the masonry must come in questio

Most easily could an injury occur by a settlement of the masonry under the middle of each side and as a result of this a b

breaking down of the hatched portion in Fig. 1445, which thereby loses its connection with the other parts of the spire and with the lacking ring compression might fall in without endangering the rest of the spire. But even this would be possible with greater pressures and would be hindered by good indentation.

Wall crushed inward by the wind.

The wind pressure tends to crush the wall in, and it would therefore be opposed as above by a line of support (Fig. 1443), and this again produces at the angles a force E directed outward which must be neutralized by the load on the hip. The weight of the hip itself, even with the strengthening outside and inside is alone mostly too small for this, so that it is desirable to transfer to them the load of the wall surfaces by arches with or without openings in them (Fig. 1446), but which must not be too flat on account of the effect of the thrust. The same purpose can be fulfilled by variously shaped openings (Fig. 1447), which at the same time reduce the surface affected by the wind pressure. The openings are also statically not without importance.

Just on slender spires, which have but a small ring compression, is most easily possible in the lower parts a crushing of the walls inward by the wind. Then in order to resist the forces E pressing outward (Fig. 1443), there often does not suffice the weight of the hip even by the addition of the weight of the walls, so that greater stiffness against bulging must be given by projection of the ribs externally and internally, so thatin a diagonal section may be formed a line of support as in Fig. 1448. This line of support can then increase the thrust slightly at the base of the spire (which does not injure the abutment, since this occurs only on the windward side), further requires the line of support, so that the upper part of the spire acts as a connected and loading mass, and hence a reduction of the thickness of the walls above is not favorable.

For walls much too thin this also is not sufficient, for the stress from the wind is nearly in inverse quadratic proportion to the thickness of the walls, and there are only two expedients; the flexure stress in the wall or the projection of strengthening rings in the intermediate ribs.

Resistance of the walls to bending.

The bending stress assumes the existence of a certain tensile resistance of the masonry. It is well possible to count on that

that in this case for carefully executed masonry without cracks or strong pressures, in a moderate degree, for the tension occurs in a horizontal direction, where besides the resistance of the mortar the friction of the indented and load stones opposes, while For tension in a vertical sense the mortar in the bed joints comes in question. But if one desires to arrange so that tension shall not need to be relied on at all or only in the heaviest storm, then for thin walls as an extremely effective means of stiffening is the use to be recommended of compression rings most simply projecting inside (Fig. 1449).

Stiffening rings.

These are spaced eight to twelve times the thickness of the walls, 20 to 50 cm thick in the direction of the height and with a horizontal width of 1/15 to 1/18 the width of the tower at t the place considered, if the ring is found inside; but 1/12 to 1/15 if it remains internally octagonal. (In this thickness is included the thickness of the wall). The thin wall acts under the effect of the wind and also of its own weight between the rings above and below like an ascending straight arch. For very large spires it may be further required to arrange one or two middle strengthening ribs extending downward on each side surface in addition to the angle ribs (Fig. 1449), to which is given somewhat smaller dimensions than those of the rings.

Thickness of the walls.

If the walls of the spire have been divided by such ribs and rings into panels, whose dimensions at most are 8 to 10 times the thickness of the walls, then can the latter be restricted to 1/24 and even to 1/36 of the width of the tower, while otherwise they should not be made lass than 1/16 to 1/20 of the width, especially when the hips also remain without ribs.

Of the oldest examples may be mentioned; the unperforated spire of the Liebfrauen church at Worms (Figs. 1411, 1411 a), whose walls are 1/19 of the width (abutment walls beneath are of rubble 1/4 to 1/5 the width and are moderately opened), the perforated spire of Freiberg tower (Figs. 1406, 1428), whose walls are 43 cm thick for about 11 m width and must be termed quite bold, since the hips project but little, and the rings or bands between the traceries not at all. In a strong wind the Freiberg spire is exposed to strong stresses, which would not be the case with strong rings, even with thinner walls. Also the high and

narrow piers of the belfry are scarcely 1/6 of the clear width and are to be termed very bold abutments.

Calculation of the thrust.

The thrust of polygonal spires is again calculated by the formula; $H = G \cot a$.

If then G = the entire weight of the spire, then H = the corresponding thrust at the entire circumference of the base; conversely if G = weight of one side of of a angle (thus = 1/8 the weight of the spire for the octagon), then results only the thrust belonging to this part. As the angle a is to be taken according to circumstances the inclination of the side surface or t that of the hip, which is somewhat flatter, or a value lying between the two is to be used. If the weight of the spire is mostly carried down by the hip, then must the angle a correspond about to the inclination of the hip; since this is the most unfavorable case for the amgnitude of the thrust, thus it is well to calculate with it for safety. If one also makes the somewhat too unfavorable assumption that the thrusts occurring for an eighth of the spire act with their full amount in the direction of the diagonal, then has been taken an assumption as a basis, by which the abutment piers will not be too weak.

Naturally the aputment pier or tower wall must be sufficiently strong, that it may resist also the wind pressure striking it and the sfire. If the angle piers of the tower are connected together at certain heights by masonry, it is unnecessary to investigate the stability of the separate piers, but that of the entire mass; (thus of the entire hollow prism of the tower), whose stability against wind is considerable larger (p 626). Otherwise the calculation of the abutment is completed just as for that of the vaults.

Calculation of the longitudinal compression.

The longitudinal compression in the covering surface and ribs acting downward is calculated by the formula:- $S = \frac{G}{\sin a}$.
In regard to the values of G and a the same is true, that was just stated concerning the thrust. Whether the horizontal compression constantly increasing downward acts more in the sides or is transferred to the hips depends on the construction of the spire as shown (p 609 above).

Calculation of the ring compression.

The ring compression, if the weight of the spire (or the long-

longitudinal compression) is pretty uniformly distributed over the perimeter, is transmitted in about a circular form, but if the weight on the contrary is exclusively carried down in the hips, as for many perforated spires, then is formed a compression polygon, whose angles lie at the hips. For intermediate cases results a polygon with sides somewhat curved outward.

In the first case for the compression circle the compression is:-

1. $U = \frac{G \cot a}{2\pi} = \frac{g \cot a}{6.283}$.

For the compression polygon it is:-

2. $U = \frac{g}{n} = \frac{\cot a}{2 \sin \beta}$.

Here g = weight of the ring cut out from the spire, a is again the angle of inclination, which in the first case is betwwen t that of the side and that of the hip, and in the second case is to be taken that of the hip. n = number of sides of the polygon, thus = 8 for the octagon. β = angle at the centre for one side of the polygon, thus = 22 1/2 for the octagon, and consequently sin = 0.3827. Then formula 2 will become for an octagonal spire;

2 a. $U = \frac{g}{8} \times \frac{\cot a}{2 \times 0.3827} = \frac{g \cot a}{6.123}$.

If there be inserted in formula 1 for a the angle of inclination a_0 of the side and in formula 2 a the inclination a_1 of t the hip, then will be obtained the upper and lower limiting values for the ring compression in the octagonal spire (see Table).

For a spire without openings the compression U acts in the entire height of the ring considered, which may be assumed 1 m high in calculating example 1.

Stresses in perforated spires.

For perforated spires the height of the rings to be considered is arranged according to the kind of openings, as in the hatched surface in Fig. 1450. Since where the width of the ring is narrowed as at a b, the ring compression must be transmitted through this small cross section. It is similar for a spire entirely divided into hib ribs and bands is in Fig. 1451. For this is found by formula 2 the ring compression, that the bands receive lengthwise, when the weight g is inserted for a horizontal piece of the spire from centre to centre of the rows of panels.

Such a spire is a completely developed framework in space with members all compressed. The ring pressure or correct polygonal compression is received by the series of bands, and the longitudinal compression by the hip ribs, to which the bands transfer their own weight and that of the panels resting on them.

To calculate the magnitude of the longitudinal compression accordingly in the formula:- $S = \frac{G}{\sin a}$, and to be inserted for G the weight of an eighth of the spire and for a the angle of inclination of the hip. Under such assumptions is found there, H = G cot a = horizontal thrust acting at each angle on the wall of the tower.

The band best consists of one long stone with sufficient resistance to bending, so as not to break. But if it must consist of several pieces, then can it easily exert a thrust on the angle piers like a straight arch, whilh tends to bend them outward. it is then advisable to arrange the tracery in the panels so t that it supports the middle of the band. For very wide panels can be added even intermediate ribs carried down for this purpose. The tracery in the panels serves in just the same manner for resisting the wind as the X-braces of the wooden spire, to which these perforated stone spires in general are very nearly allied. (See below).

Comparison of stresses and thrusts of spires of different heights.

To give a clear view of the stresses and thrusts of polygonal spires of different heights, there is established the following Table; the first flat roofs are scarcely erected, but are added for comparison. Generally the stresses vary little from those of conical spires of equal height.

Stresses in octagonal stone pyramids.

(See Table on p. 612).

G is the total weight of the spire above the point considered.

Example. A brick spire 25 cm thick is octagonal with 6 m internal and 6.5 m external width, with a fourfold height of 26 m outside and 24 m inside. A cu. m of brickwork weighs 1800 kil.; the magnitudes of the stresses and thrusts are to be calculate. Volume of a solid octagonal pyramid = $0.829\ B^2 \frac{h}{3}$; the existing hollow pyramid has a volume accordingly with a difference from the solid of ; $0.829\ (6.5^2 \times \frac{26}{8} - 6^2 \times \frac{24}{3})$ = 65 cu. m in round numbers, so that this weighs 65 × 1800 = 117,000 kil = G, and 1/8 of this weighs 14,625 kil. According to the preceding Table the longitudinal compression at most = $1.009\ \frac{G}{8}$, here = 14,757 kil, or at least = $1.008\ \frac{G}{8}$ = 14,720 kil. This is distributed over 1/8 of the base, which is an area of $\frac{1}{8} \times 0.829(6.5^2 - 6^2)$ = 0.647 sq m or 6470 sq. cm and for uniform distribution = $\frac{14730}{6470}$ =

about 2.3 kil per sq. cm, but would be considerably more with perforations or unequal distribution. (Strictly taken it is not the area of the plan, but that of a section perpendicular to t the rib, that must be taken in the calculation, but this makes a scarcely noticeable difference for steep spires).

To find the greatest ring compression, there is considered a ring 1 m high, whose volume is the difference between the solid and hollow pyramids being shortened about 1 m is calculated at about 5 cu. m, which thus weighs 9000 kil. According to the Table the ring compression lies between 0.02 × 9000 = 180 kil and 0.22 × 9000 = 198 kil. The cross section of the ring is about 1/4 sq. m or 2500 sq. cm, and thus exists per sq. cm the extremely small compression of 0.072 to 0.079 kil, thus not quite 1/10 kil per sq. cm. The ring compression for the entire height of the pyramid at most amounts to 0.22 × 11.7,000 = 2574 kil, and just as great would be the tension in a ring of the base to resist the thrust.

The thrust is computed for each angle to be at most = 0.135 × 14,625 = 1974 kil, but it would probably remain under 1900 kil, and the abutments must suffice to receive it (see above conical spires and vaults.

Hexagonal and square spires.

The data and formulas for octagonal spires apply likewise to spires of other polygons.

The hexagon and pentagon do not often occur (at Pressburg two monastery churches present an example of each), but on the contrary square spires are not rare in the early time. The less t the number of sides, so much the more are the difficulties increased, since the important ring stresses are incomplete. Particularly unfavorable appears the wind pressure against large surfaces. The expedients mentioned, such as stiffening rings, strengthening the hips and the middle ribs, the latter eventually extending to the vertex and even in arched form could thereby serve to reduce the otherwise very great thicknesses of the walls to be employed.

Spires with curved sides, domes.

Possibility of different cross sections.

Polygonal or round stone roofs, that exhibit concave contours in elevation instead of straight lines (Fig. 1452, left), have greater ring compression but also greater thrust (compare forces

I and II of Fig. 1452); conversely for a convex external outline the ring compression is reduced, which may even become ring tension, and accordingly the thrust on the abutment is accordingly less (compare forces III and I in Fig. 1452). The concave spire on account of the greater ring compression has more ability to resist unsymmetrical loading, and conversely the convex spire exerts a smaller thrust on the abutment. Thus it depends on existing circumstances, which of the two deserves preference in a given case.

Even ogee spires may be erected (Figs. 1453, 1454). The direction of the pressure on the abutment also here again coincides with the lower tangent, and thus the thrust in Fig. 1453 will be greater than in 1454. The ring stress at the different heights depends on the course of the curvature; it is quite possible to build spires in the forms of Figs. 1453 and 1454 without ring tension occurring at any height, the outline must show not too strong a curvature outward and nowhere approach too nearly the vertical. Forms like Fig. 1455 on the contrary will have ring tension along the considerable distance a b, but since this is avoided as much as possible in masonry, such spires or domes a are opposed to the requirements of masonry construction; only by special expedients or a waste of masses, while the interior is increased to form a true dome (see right side of Fig. 1455) can it be made permanent. Domes may be so formed that the ring stress shall everywhere be 0 (see p. 55 and Fig. 126), yet domes to be preferred have ring compression.

Calculation of thrust and ring stress of any domes.

Since then ring tension in masonry is avoided as much as possible, the calculation readily gives an account of ring compression, and it is important to learn a simple procedure by means of which the magnitude of the ring stress is to be found in any dome at any height (Fig. 1456).

With the assumption that the ring stress takes care of this, that the longitudinal compression everywhere approximately passes in the direction of the tangent downward, at the point to be examined is cut out by horizontal planes I-I' and II-II' a not too high ring. The inclination of the tangent at the height I-I is termed a_1, that at the height II-II being a_2, and just as for the cone (p. 605) the thrust in the entire circumference at the height I-I is; $H_1 = G_1 \cot a_1$, and at the height II-II is;

$H_2 = G_2 \cot a_2$. The thrust H_d produced by the joining of the ring is the difference between H_1 and H_2; $H_d = G_1 \cot a_1 - G_2 \cot a_2$.

So long as this H_d remains positive, ring compression exists, but when it is negative, ring tension occurs. But the magnitude of the ring stress is easily found by the formula:- $U = \frac{H_d}{2\pi}$.

These relations are true for any outline of the dome, even when within the ring appears a break turned out or in. The lower the ring is taken, the more accurate is the result, yet one need not be too careful about this, and for high domes may generally cut out without hesitation rings 1 m high without injury to the accuracy usually required.

For domes with polygonal plans apply the same relations with the consideration of the little variations and the angle of inclination already treated. The horizontal thrust for the entire circumstance is again $H = G \cot a$, when G is the total weight of the dome, and the ring stress is found as just shown by the difference H_d of the thrusts, but where according to circumstances its magnitude lies between $U = \frac{H_d}{2\pi}$ and $U = \frac{H_d}{n\ 2 \sin \beta}$, (n is the number of sides of the polygon, and β is half the angle at the centre for one side). By all this is it shown that the calculation of masonry cones, pyramids and domes with sufficient accuracy for practice belongs to the simplest problems.

7. Wooden spires of towers.

Wooden spires of masonry towers.

The defects and difficulties mentioned above that are connected with the construction of masonry spires in brickwork may have led to the so frequently occurring wooden spires covered with slates or metal in regions where brickwork is native, as well as the fact that not all stone is able to resist the injuries of weathering in the exposed position of the spires. Both reasons may continue in the present, but the advantage of economy, that was peculiar to the wooden spires in the middle ages, no longer exists in modern times, but it is rather the contrary in countries that furnish stone of sufficiently good quality, even when men would make the walls of the belfry thinner with regard to the entire removal of all thrust by the wooden spire, that is however possible in only a slight degree (p. 627).

Inclination.

The advantages of seen inclination mentioned above also continue for the wooden spire in more than one respect, and therefore

they have the same proportions as the stone spires, and indeed in the later periods of the middle ages there were favored almost too slender forms for wooden spires. Therefore we mention the spire of the church in Wetter dating from the first part of the 16 th century, which shows the proportions of 1 : 8 1/2.

Requirements for the woodwork.

In the construction of wooden spires, three points are chiefly to be kept in mind.

1. The arrangement of immovable base and neutralization of t the thrust of the rafters.
2. Security against overturning.
3. Stiffening the wooden walls against any bending, turning etc.. The fastenings of the woodwork that must fulfil these different requirements may be stated, assuming an octagonal ground form.

a. In the direction of the diagonal of the octagon.
b. In the direction of a cross inscribed in the octagon. Fig. 145
c. In the direction of the sides of the polygon.

Base of the spire.

If we first take the direction for the base, there results f for a a framework of timbers running diagonally to receive the rafters and struts (Fig. 1457). At most two diagonal timbers may extend through and be halved together at the middle, and t the others must be placed against cross beams, and for strengthening it is best to place two timbers beside each other for the continuous diagonals. The jack beams must be connected to resist tension to receive the thrust of the rafters.

For b results the layer of timbers shown in Fig. 1458.

For c then by avoiding all through timbers occurs an immovable series composed of wall plates halved at the angles (Fig. 1459), on which are fixed the beams to receive the rafters and struts. If such an octagonal series lies on the walls of the square tower (Fig. 1459, right), then the wall plates at the four corners may be supported by corbelled masonry or brackets, but this is generally unnecessary and a free bearing of the short timbers is permissible.

If we now consider the thrust of the rafters and struts as a analogous to the thrust of the vault, the resistance of the abutments is here replaced by tiebeams (Figs. 1457, 1458), or by a series of anchors (Fig. 1459). The series of wall plates is

also very useful as a basis for the tension framework. (Fig. 1457). If the thrust of the rafters is certainly neutralized, at mose can come in juestion still merely a sliding of the entire base (by wind), which is made almost impossible by the friction of the wood on the masonry, even if no anchoring exists, but on the contrary it is not excluded that with mortar still soft, a violent storm may slide the upper courses of masonry and the spire.

To ensure the spire against overturning must serve its own weight or if necessary an anchoring to the masonry.

To prevent the hip and jack rafters from bending, and generally to make impossible any moving and crushing of the sides of the spire, struts and purlins must be inserted, which may again lie in one of the three directions (Figs 1457 to 1459).

Diagonal bracing.

The bracing corresponding to Fig. 1457 first consists of 4 X-braces placed over the diagonals (Fig. 1460), each of which is halved on an opposite rafter. These X-braces are so arranged as to cross each other at the middle, and they are repeated two or three times in the height of the spire. Above the last crossing then the stem of the spire, that is joined by the angle rafters with mortise and tenon, like the ribs of a vault at the keystone. The stem of the spire then rises above the junction of the rafters and bears the cross crowning the spire. Further the X-braces are also often replaced by collar beams and girts. For great s spires, the angle rafters can also be strengthened by parallel struts directly under them or separated by a space, into which the X-braces are also halved.

Stiffening by crossed beams.

The second direction of the connection is such that the braces just described do not lie in the diagonal planes, but in the p planes of the cross (Fig. 1458). Instead of these there may be placed at certain divisions of the height of the spire (3 to 5 m) timbers crossed as in Fig. 1458, so that the separate beams strike the angle rafters. For more secure support of the timbers and for better stiffening are then added braces (Fig. 1462).

The second layer of beams strike the angle rafters at the points a and a', the third at the points b and b'. The point a is supported by the strut s, which is halved to the brace x, so t that it later secures also the point p of the same timber. On

the timbers a a to those parallel are laid the two timbers f f (or f″), which again bear the girts g and g″. The latter then receive the construction consisting of the timbers b b and b′b′ consisting of a part of a brace, which is repeated upward until the narrowing of the spire prescribes a different and simpler system of construction composed merely of girts.

Close beneath the apex the timbers of the cross-shaped framework (after Fig. 1458) are so close together, that they serve to clamp between them the stem of the spire carried down far , (also termed the king piece, and thus hold it secure.

Bracing in the planes of the sides.

The third bracing lies in the direction of the sides and consists in this, that at certain distances determined according to the dimensions of the rafters, at distances in height amounting to 3 or 4 m (Fig. 1462), there are formed horizontal bands consisting of 8 pieces, that join the angles at a, b, etc., and are each supported by 4 X-braces c, d, alternating in the sides. It is evident from Fig. 1462, that the X-braces are placed parallel to the plane of the wall of the spire, and its external surface lies inside the inner edges of the rafters, and that t the fall of each cross inward, i.e., that of the lower c is resisted by the girt of the cross starting thereon like d.

Likewise here is it useful to double the angle rafters (Fig. 1463) where the inner is separated from the outer by a space a and connected together by ties z. The construction just described of the X-braces then stands under the inner struts. The ties become girts for the support of the jack rafters, and by an extension of the ties outside (a in Fig. 1463) passages with balustrades can be formed, just as between the internal struts and the walls of the spire exist internal passages. When the struts are placed directly beneath or with a very small interval under the hip rafters, then the girts and cross lie between them, and thus produce particularly strong connections ob all parts. There is certainly to be taken care to avoid any bending inward of t the angle timbers, either by flexure of the hip rafters by means of ties or bolts, or by a corresponding layer of beams above each series of girts, since otherwise the ascent of the spire will frequently be made.

Space is lacking here for us to give an entire development of certain constructions, which are therefore not given at length.

For example there are sometimes found instead of the eight internal struts (Fig. 1463) but four (Fig. 1464), which rise as in the lower part of the spire as a frustum of a pyramid, and servo for a safer placing of the crossed or even also the diagonal b braces. They are particularly suitable when wide and narrow sides of the spire alternate as on the south tower at Jerichow.

Concerning the connections of the timbers it may only be stated, that at the crossings to avoid deeply cut halving, the timbers do not lie in one plane, but only lose a part of the dimensions. The ends of the timbers are allowed to project, where space permits; where this is impossible, it is preferred to use the halving represented in Figs. 1465 and 1465 a instead of the usual concealed tenon.

The wooden framework of the spire thus formed is then covered on the outside by nailed sheathing on laths, which receives the covering.

Covering of the roof.

By the use of slates is obtained a decoration of the surfaces by patterns with slates of different colors, but less effectively only by the mode of laying. Securing the angles of the hips is most simply produced by overlapping of the covering on one side beyond the other, better by a variation of the mode of covering the surfaces, about so that on each side of the angle extends a separate row of slates, that is either the French or German mode of covering the surfaces (Fig. 1395). But the best security for the angles results from strips of lead fastened o over the slates, which essentially contributes to the animation of the whole, particularly if them are ornamented by lead crockets in relief. Durability and also the external ornamentation of the spire is enhanced by a lead covering, whose sheets run horizontally, or are laid in an oblique direction on many French towers and thereby form a pattern.

Covering and crowning the stem of the spire.

At the base of the pointed ending of the stem of the spire a are placed iron bars in the form of an inserted V, so that the branches extend down on the wood and are fastened there by nails or better by iron rings placed around over them. (Fig. 1666). These rods there form the vertical branch of the crown. For larger dimensions four iron bars are fastened on the stem of the spire, which are then clamped around this directly placed vert-

vertical iron rod and connected with it by indents as well as by rivets and rings. The apex of the spire on account of the small dimensions of the surfaces no longer permitting the placing of separate slates, and also to make the joint between slates and iron tight, is covered by lead or copper.

This metal covering is terminated by a lenticular knob, which is likewise of lead or copper and is indeed hammered up, so that it consists of two halves a and b (Fig. 1466). This knob is then attached to the iron rod, best under a wrought projection on the same (c in Fig. 1466). The lightness of the effect can be enhanced by extending the rod of the spire beyond the mathematical apex of the pyramid, and the ornamentation of the whole by a r richer treatment of the lead covering, of the knob as well as of the ironwork of the cross.

Very helpful here is the easy hammering of the lead in relief, by means of which the knob may assume similarly rich forms as in stone (Figs. 1093 to 1095), or merely in such an extremely characteristic mode of treating the metal, it is best by separate spherical and prismatic projections, whose outer openings are closed by a soldered sheet of lead (Fig. 1467).

It further makes possible richer crowning by leaves or buds after the style of the crossflower, by the placing of a second lead cap above the knob (Fig. 1468) to which are soldered the separate leaves of the crown. The leaves are cut from lead sheets as developed, and then bent according to their relief. The lead covering of the stem of the spire may likewise be ornamented below the knob by crockets soldered to the angles (Fig. 1473). As stated, the ornament of the crockets can be carried down on the lead coverings of the hips of the spire.

Smaller crownings are satisfied by a knob or the first described form of crossflower, where the stem of the spire or the iron rod fixed on it ends beneath the covering made by the terminal knob (k in Fig. 1468). Yet as a rule the latter is still far exceeded by the cross.

Cross and weathercock.

Also the ironwork of the cross is capable of the richest ornamentation and contributes essentially to the impression of the whole. We note before all other matters, that the cross is entirely wrought and never cast, and must generally bear a cock on its apex. Contrary to this the very frequent combination on old

works of the cross and weathercock is never to be employed.

The ornamentation of the cross consists in a finer forging of its ends, in the varied treatment of the angle bands that connect the arms, and for greater height in the addition of two or four iron scrolls riveted to the foot of the cross or fastened by iron rings and projecting far outward (Fig. 1469), whose ends are again forged into leaf or flower forms or are connected with them. Small towers are often contented with wrought scroll crownings without the cross. The iron rod has recently been usually utilized for the addition of a lightning rod, as also for stone spires.

Dormers.

The access necessary to the outer surfaces of the spire requires the repeated arrangement of dormers, which at the same time substantially contribute to the animation of the tower. In the simplest shape these form little gable roofs projecting on corbels, whose woodwork is entirely covered by slate or lead (Fig. 1470). The effect of this gable hood is substantially increased by a middle part that rises beyond the apex of the gable like the stem of the spire, or by the placing of actual spires which usually form the sole roof of the dormer, when two or three sides of the polygon projected over its front (Fig. 1471), thereby forming little turrets, that grow out of the great spire. A peculiarly treated example of this kind is formed by the spire of the Teyn church in Prague, that on four sides exhibits little hexagonal corbelled turrets about like Fig. 1472.

Passages and intermediate stories.

Likewise on wooden spires may be formed horizontal divisions of the spire either by external passages or by an intermediate story with vertical walls interrupting the inclination. The latter are placed over the face of the lower part of the spire, are projected outward, or also are recessed, so that the upper surface of the spire falls in the line of the lower. The external passages are formed b: projecting beams supported by plates and extending out according to the desired projection of the balustrade, receiving the floor of the passage and sometimes bearing a parapet above which rise pinnacles, whereby however the pinnacles must be connected above the rafters of the upper wall of the spire (Fig. 1463). The intermediate story, of which the towersof Notre Dame at Chalons furnish a particularly rich exam-

example, easily result from that construction of the spire mentioned on p 616 with doubled angle rafters (Fig. 1477).

Simple roofs of towers.

Wood construction further leads to certain other forms of towers more nearly corresponding to ordinary roofs, whose character is peculiar to more secular works, yet for limited means may also be employed for churches; they lead to great diversity and in any case deserve preference over the later experiments, the retaining of the typical form of spire with a squat low shape, making possible a resulting economy. There belong here:--

1. The ordinary gable roofs with stone and even with wooden gables, the latter allowing the wood construction to be seen, which for protection from the weather can be slated. The middle of the roof or the front apex of the gable are especially marked, the first by a roof turret and the latter like the dormers of the spire, by a king post rising above the junction of the rafters and receiving the cross or weathercock .

2. These roofs are almost more common than gable roofs, chiefly in the form shown in Fig. 1474, where by different inclinations of the surfaces may be obtained any desired length of ridge even on a square plan. But such roofs may also be constructed on a polygonal plan, whereby the lengths of the sides mostly determine the length of the ridge. When one is also inclined to regard this so frequently occurring form of roof as an expedient, that must replace the spire omitted from lack of means, then s sometimes by the addition of a roof turret may be given to the whole the impression intended at first. Fig. 1474 exhibits a r richer example of this kind from the tower in Champagne with angle turrets over the buttresses.

3. The intersecting gable roofs are mostly connected with a roof with turrets placed over the middle, also sometimes with a slender spire or finally with a strongly elevated middle post bearing the cross and weathervane, against which abut the four hip rafters.

Roof turrets.

By roof turrets are understood little towers, that instead of being placed on masonry or a visible wall, are supported by wooden construction under the surface of the roof from which they rise, appearing as a rule to stand astride the ridge (Fig. 1475). Its ground form may be square, hexagonal or octagonal. In sect-

sectional construction are chiefly to be distinguished two kinds. For either the spire of the turret is separated by a formal cornice from the story beneath it with vertical walls (Fig. 1478), or its angle parts are directly continued in the rafters of the spire (Fig. 1479), so that strictly taken it is treated merely as a spire extending through the roof, and the proper tower story is only indicated by the penetration of the lower part and the decoration. An example of the last kind is formed by the roof turret of the cathedral of Paris, which was erected by Viollet-le-Duc and is to be regarded as an unexcelled model in every respect (Dict. Vol. V, p. 454). It differs from the others in that the proper bracing that transfers the weight to the crossing piers at least partly rises above the roof. When the weight of the roof turret cannot well be transferred by trusses to the outer walls or the crossing piers, then in case it is not too great, it may be placed on long radiating or parallel sills, that distribute its weight over as many beams as possible. Very light roof turrets may even be borne by a well supported collar beam.

Roof turrets as a rule are entirely slated on the simpler works, and only the ends of the stem of the spire rising above the spire or gable are covered by lead. An example of this kind from the church S. Maria in Marburg is shown in Fig. 1476. Richer f forms result with an entire covering of lead, and in such manner can be attained a magnificence not inferior to that of developed stone construction, even surpassing it in at least a visible boldness. As peculiarly splendid examplesbesides the previously mentioned new roof turret in Paris, are also to be mentioned thuse belonging to the 14 th and 15 th centuries church of the Minorites in Cologne and the cathedral of Amiens.

8. Stresses in wooden spires.

Wooden spires are statically so nearly allied to stone spires, that the formulas deduced for the latter may also be scarcely changed and retain their value here. An essential difference is only to be seen in this, that the tensile resistance of the wood can be utilized, which is particularly manifested in the possibility of easily neutralizing the thrust in the ends of rafters without the aid of abutment walls.

Instead of a repetition of what was stated for stone spires, an example may serve here instead of further explanations.

Example. The dimensions of the timbers of a great spire covered by slate are to be calculated, that including all structural parts weighs 120 kil per sq. m of its surface, and that for 10 m width of base measures 40 m in height of side (measured on t the inclination).

Since the side of an octagon 10 m wide measures 4.15 m, each surface of the spire has an area of $\frac{1}{2} \times 4.15 \times 40 = 83$ sq. m, which corresponds to a weight of $83 \times 120 = 10,000$ kil in round numbers, so that the entire spire weighs 80,000 kil.

Neutralization of the thrust.

Thrust at the supports. The thrust at the entire perimeter is G cot a. (p. 610). The angle a of inclination of the side is 82.9°, of the hip is 82.3°; for both it is sufficiently accurate to place cot a = 0.13, so that the total thrust = G cot a = $0.13 \times 80,000 = 10,400$ kil. It will be assumed that besides the eight hip rafters, there are 3 jack rafters in each side, thus being 32 rafter is all, each of which rests on a tiebeam, and each of the latter with uniform loading has a thrust of $\frac{10400}{32} = 325$ kil. If the thrust came at the angles alone, each of the eight beams in Fig. 1457 would have a tensile stress lengthwise of $\frac{10400}{8} =$ 1300 kil. (In the cross-shaped beams in Fig. 1458 would be about the same). Since 1 sq. cm of the cross section of wood may be stressed by about 80 kil tension, there would result a cross section of $\frac{1300}{80} = 17$ sq. cm in round numbers, thus a small strip 4 × 4 cm would suffice; for flatter spires would be required s somewhat greater values, and even smaller for steeper spires. It is evident that the dimensions of the tiebeams are less importand than a sufficiently reliable fastening of the ends, especially at the joints and crossings of the tiebeams. In spite of the small forces, this point must not be neglected, for otherwise even the tiebeams transfer the thrust of the rafters by means of their friction to the masonry, which it is desired to avoid. (Although the walls are strong enough in many cases to receive the thrust.

More permissible is always the neutralization of the thrust by a series of doubled wall plates (Fig. 1459), even if a tie or cross framework is found over them. The tension in this series according to p. 605, 611, is:-

$$U = \frac{G \cot a}{8 \times 2 \times \sin 22\frac{1}{2}°} = \frac{80000 \times 0.13}{16 \times 0.38} = 1700 \text{ kil in round numbers.}$$

If for safety it is assumed that one of the wall plates, indeed

the inner, is sufficiently strong to receive this tension, then is required a cross section of $\frac{1700}{80}$ = 22 sq. cm, thus dimensions of 5 × $4\frac{1}{2}$ cm. But since it is usual to give wall plates a four-fold to eightfol cross section, full security exists, if they are only in a measure fastened together by tenoning or halving, and if the position of the fibres in the two series is suffociently long not to be sheared, Taking the resistance of the wood to shear in the direction of the fibres at only 10 or even 5 kil, then with 12 cm breadth of the plate only $\frac{1700}{10 \times 12}$ = 14 cm to $\frac{1700}{5 \times 12}$ = 28 cm length of fibres, i.e., 14 to 28 cm distance between the the two planks would be required. Besides at the c crossings the through wooden pins would do their work.

Safety against overturn by wind.

Overturning by wind. If it be assumed that the wind acts with full pressure on the triangular vertical section 10 m wide and about 40 m high, overturning would follow if the overturning m moment $W_o \times 10 \times \frac{40}{3} \times \frac{40}{2}$ were equal to or greater than the resistance moment ; which would be 80000 × 5.0 for a wind pressure W_o = 150 kil per sq. m. If the oblique action of the wind on t the side were considered, its effect would be only 0.707 times as much, and then overturning would only result for a wind pressure of 210 kil per sq. m. Since the maximum wind pressure observed in Europe amounts to about 200 kil per sq. m, then the s stability would suffice, but still a slight anchoring of the 8 hip rafters to the masonry can be recommended. This would certainly be necessary for lighter towers.

In order to show how the dimensions of the anchors may be calculated for the case, that this spire with metal covering and extremely light woodwork weighs only 60 kil per sq. m, thus 40000 kil for the whole, and that it must resist a wind pressure of 200 kil per sq. m on the full vertical section. It may then be further assumed that only the two wall anchors farthest from t the pivot edge, about 9.5 m distant from it, shall act. If Z = tensile stress in one anchor, then by equating resisting and overturning moments:-

$$2 Z \times 9.5 + 40000 \times 5 = 200 \times 10 \times \frac{40 \times 40}{2 \times 3}.$$

Hence Z is computed to be 17500 kil, i.e., each vertical rod with a stress of 1000 kil per sq. cm must have a cross section of 17.5 sq. cm, and be carried down so deeply that its lower p plate shall be loaded with 17500 kil or 7 to 10 cu m of masonry

according to weight. Since the anchors at the other angles assist, even if in the second line, the anchors could be made somewhat lighter; generally will seldom occur such great danger of overturning, since spires of such great size would be heavier. Yet the example must show how important the anchoring may become in certain cases. In the middle ages it was usually effected by extending the correspondingly connected timbers one story below

Compression in rafters.

Stress in rafters and struts. According to p 604, 611, there acts longitudinally in the entire length of the rafters a compression $\frac{G}{\sin a}$, thus here = $\frac{80000}{0.99}$ = 81,000 kil. In each of the 32 rafters would average about 2500 kil, or if the 8 hip rafters alone receive the compression, there would be on each 10,100 kil; with 60 kil compression would be required 170 sq. cm or 10 × 17 cm. On account of the danger of buckling in consequence of the great free length, and especially by the increase of the compression by the wind, larger dimensions are necessary.

The most unfavorable stress would occur from wind, if the spire were ready to fall and its entire weight rested on the two hip rafters or angle posts at the pivot edge. Each of these timbers must then support 40,000 kil, and thus with an allowance of 60 kil it would require 666 sq. cm or be about $22\frac{1}{2}$ × 30 cm in cross section. With proper struts buckling could only be possible in the free length between each two girts, but with such large timbers and girts not too far apart (3 to 4 m), it could scarcely come in question; conclusions concerning this would be given by the formula given on p 494, in which is to be inserted for wood:- s = 10 and E = 100,000 (for wrought iron s = 5 or 6, E = 2,000,000). For such great spires instead of such very heavy hip rafters might well be employed only moderately large rafters with a strong corner strut underneath (Fig. 1463). The calculated dimensions could be somewhat reduced with regard to the aid of the other jack rafters, especially for anchored spires, so that it could be regarded as sufficient to make the bearing hip rafters and struts; for spires 8 to 10 m wide about 20 × 25 cm, for 6 to 8 m wide, 16 × 20, to 18 × 23 cm, for 4 to 6 m wide, 16 × 18 to 16 × 20 cm. In this proportion can also be reduced the dimensions upward, which makes it much easier to obtain long timbers.

Jack rafters with 3 to 5 m between their supports only require

to be made as large as the ordinary rafters of roofs, to provide for flexure by weight of covering and wind pressure.

Ring compression. Except for the effect of the wind, the compression in the ring is very small, and is computed (p 611) by the formula:-- $U = \frac{g \cot a}{6.123}$. If the first ring above the base is about 9 m wide and the distance between rings is 4 m, there belongs to this ring a horizontal portion of the tower of about 120 sq. m area, which for 120 kil per sq. m has a total weight g of 14,400 kil. Since cot a = 0.13, thus there results a compression in the ring timbers of $U = \frac{14400 \times 0.13}{6.123} = 306$ kil. With regard to the wind, it is well to make the ring timbers strong enough, that in the most unfavorable case half the wind pressure acting on the corresponding part can be transferred. The part of the height corresponding to the lower ring presents to the wind a surface of about 4 × 9 m = 36 sq. m. Id the wind pressure is taken at 200 kil per sq. m, or on account of the somewhat oblique direction it is taken at only 0.707 × 200 = 141 kil in o calculation; thus it amounts to 5200 kil in round numbers, thus producing 2600 kil compression in the ring timber. Hence a cross section of $\frac{2600}{60} = 43$ sq. cm or 6 × 8 cm, but on account of the danger of buckling (see above), with a free length of 3.6 m, 15 × 15 cm is to be employed. Since the upper rings are stressed far less, the usual dimensions of timbers are always sufficient; a good connection at the angles suitable for transmission of a small tension is also here of more importance than great dimensions of timbers.

Stresses in the struts.

Wind struts. For the sole action of its own weight the spire can be built with small rafters and girts. The effect of wind, as we have seen, compels these timbers not only to have larger dimensions, but also requires other struts, which according to Figs. 1460 to 1463 may lie in the interior of the spire or in its enclosing surface.

The X-braces in the surface (Fig. 1462) have to prevent all bending and distortion of the surface; the maximum stress in the X-brace must occur when it is required to transfer alone to the nearest hip the entire wind pressure calculated for the girt, thus being for the lower panel 2600 kil. On account of the inclination, which may amount to 45° in the lower panel, this pressure is increased by the corresponding resolution of forces, in

the proportion of $\frac{2600}{\sin 45°} = \frac{2600}{.707}$ = about 3700 kil. On account of the great length which may be fully 5 m, the danger of buckling also increases, so that according to the formula for buckling (see above and p 494), a cross section of about 19 × 19 cm is computed. If the braces are firmly fastened at their crossing without too much weakening, the danger of buckling is reduced if the ends are also firmly fastened against tension (Fig. 1465), and then the countrebrace may act to relieve by its resistance to tension. Therefore dimensions of 16 × 20 cm abundantly suffice, and they may be made smaller in the upper portion and on smaller towers.

It is a defect that the X-braces in the upper portion of the tower are very steep and thereby lose much of their effect. If they have there only a lesser importance, then it may be preferable in many cases to set them with their ends not against the girts, in a somewhat flatter direction directly tenoned into t the hip rafters or struts. Thereby will also be avoided the interfenence with the cross grain of the girts. If the X-braces alternate in the panels up to 2/3 the height, then crushing can occur only by shrinkage of the timbers and loosening of the connections, for example under the effect of the wind the polygonal plan may be flattened somewhat at the mid-height of the tower. To prevent this the X-braces can be employed above certain or all girts (Fig. 1458), but not as usual be placed between the girts, but tenoned into them and then tenoned sidewise into the hip rafters or struts. Some horizontal beams are further desirable for ascending. It is further noted that also the board sheathing with two nails in the end of each board forms a very efficient wind bracing, that fully replaces the X-braces in the upper part of the tower.

Bracing as in Fig. 1460 has the advantage, that it connects the hips struck by the wind directly with those lying opposite, but on account of their great length they bend easily under compression, and it may therefore be recommended to transfer the compression by timbers, while the oblique timbers then become tension members.

When the bracing is incomplete, then aside from destruction by wind or injurn to the covering by strong flexure, a gradual change of form of the spire occurs. The hygroscopic variations in the timbers, the repeated wind stresses in one side, and the

varied warming by the sun's rays may act together to produce c curvatures and even twisting of the entire spire, as such occurred in a very surprising manner on the towers at Gelnhausen.

Iron spires.

Iron spires of towers are likewise constructed as in Fig. 1462 with rafters, girts and X-bracer; the latter are in tension while rafters and girts are in compression. The calculation of i iron towers, which are combined with small use of material with very ornamental sections, can be carried out with sufficient a accuracy in the manner previously described.

9. Stresses in the walls of towers.

Compressile stresses due to their own weight.

For towers their own weight, the thrust of the masonry spire and vaults with the wind pressure come in consideration.

Prismatic and pyramidal structures.

For the considerable height of towers, the compression under their own weight plays a very important part and even draws very narrow limits in case of rather weak materials. If it is desired to erect walls of uniform thickness or prismatic piers with tamped clay or lear lime concrete, that weights 1500 kil per cu. m and to which can be applied a compression of only 2 kil per sq. cm, the permissible height would be calculated as follows. A cube of 1 m side would load the area of 10,000 sq. cm with 1500 kil, thus with $\frac{1500}{10000}$ = 0.15 kil per sq. cm. For each additional cube pladed on this, the compression would be increased by 0.15 kil; then to reach the allowable compression of 2 kil per sq. cm, only $\frac{2.00}{0.15} = 13\frac{1}{3}$ cubes could be placed, i.e., on the ground form, a vertical wall of this material could be built only 13 1/3 m in height.

In like manner brick masonry weighing 1600 kil per cu. m and with 7.5 kil per sq cm allowable compression would be stable f for a height up to $\frac{7.5 \times 10000}{1600}$ = 47 m in round numbers.

Likewise for hard bricks or clinkers weighing 2000 kil per cu. m and for 15 kil per sq. cm maximum safe compression, masonry might be built to a height of $\frac{15 \times 10000}{2000}$ = 75 m; for cut stone weighing 2600 kil per cu. m and a compression of 30 kil per sq. cm $\frac{30 \times 10000}{2600}$ = 115 m.

If weights of ceilings, etc., are added to this, the permissible heights would be reduced, and the same is the case if compression by thrusts of vaults or by wind is excentric, the com-

compression at one edge being thereby increased.

Accordingly this has the appearance that the heights of buildings of our ordinary materials had quite narrow limits, yet t this is not so, for by skilful distribution of the masses it m may far exceed the values obtained. For example if the thickness of a vertical wall be gradually reduced to 0, it may be built twice as high as for uniform thickness, and the same is the case for a hollow pyramid or a hollow cone with constant weight of covering. But if a tower be in the form of a solid pyramid or even of a hollow pyramid with thickness of walls uniformly decreasing upward, even a threefold height is conceivable, and thus for the assumptions above; for brick masonry 140 m, for clinkers and for cut stone 345 m.

These advantages did not escape the ancient masters, the Egyptians already erected their highest structures in form of pyramids, but built them almost solid, thus creating masses of stone that appear shockingly stumpy in contrast to the wonderfully light towers of the Gothic. The latter not only approximated in the main forms the advantageous form of the hollow pyramid, but even went beyond this in the suitability of the distribution of the masses, which was possible in the structures following later. Thus all further requirements such as covering the interiors, resolution of the solid walls into separate bearing piers, bracing against overturning by wind, etc., were so masterly combined together, and at the same time the stamp of an art work of such perfect form was impressed, that only the highest astonishment can be realized by works like the towers of Cologne cathedral considered from this point of view. If one considers how far is the distance from the vertically ascending tower of the Early Christian and Early Romanesque towers with their scarcely diminished thickness of walls to this statical creation well weighed in all directions, then must one be astonished by the lightness with which the old masters attained this aim.

Best distribution of the masses.

We stated that men could make possible a more suitable distribution of masses than that of the pyramids; in fact men not only could do this, but theoretically it is even conceivable to erect an infinitely high structure without the compression at the base exceeding a fixed value. There the upper parts certainly are r rapidly reduced to such small thickness, that the possibility

of construction and especially the danger of overturning very soon set a limit to the height.

The law here unavoidable, according to which a structure must be formed, that shows at each height the same compression per unit area is:-- $\log nat\ (b_2 : b_1) = \gamma h : k$.

Herein b_2 and b_1 are the areas of any two horizontal sections (in sq. m), that are distant apart by h (in m). k is the allowable load (in kil per sq. m), and γ is the unit weight of the masonry (in kil per cu. m).

If it is assumed that two areas are cut out, where the b_2 is twice that of the upper b_1, then $\log nat\ (b_2 : b_1) = \log nat\ 2 = 0.69315$. Inserting this in the preceding gives:- $0.69315 = \frac{\gamma h}{k}$, and from this follows $h = \frac{0.69315\ k}{\gamma}$. Accordingly for masonry of a given weight and a fixed permissible compression, one can calculate at what differences in height the ground area must be doubled. For example if we assume that the upper part of a tower of brickwork weighing 1600 kil per cu. m has been so designed, that it has a olad of $7\frac{1}{2}$ kil per sq. cm, thus being 75,000 kil per sq. m, and we wish to extend the tower downward without increasing the compression, we must gradually increase the ground area, so that at the depth $h = \frac{0.69315 \times 75000}{1600} = 32.5$ m, it has become twice as great. But again at 32.5 m must then the area again be doubled, thus being fourfold, etc., and likewise eightfold at the next division of the height, then sixteenfold, etc. This requirement for materials finally increases so rapidly downward, that a practical limit is soon drawn.

But in any case we see, that the heights given above for pyramids do not reach the extreme limit. For the clinker masonry mentioned with a weight of 2000 kil per cu. m, and 15 kil compression per sq. cm, thus 150,000 kil per sq. m, the ground area must be doubled at heights of $\frac{0.69315 \times 150000}{2000} = 52$ m, or for cut stone with a weight of 2600 kil per cu. m and 30 kil per sq. cm per sq. cm, $\frac{0.69315 \times 300000}{2600} = 80$ m. To erect towers of the last material 400 and 500 m high would not be so very difficult. By the help od granite or basalt, which has 1000 or even 2000 to 3000 kil ultimate resistance to crushing per sq. cm, it would be harmless to load them with 60 or even 100 kil per sq. cm or more, and it would be possible to reach such heights beside which our modern colossal towers like the Eiffel tower would seem like dwarfs. We see that our respectable cut stone need not longer

give place to iron.

We must here again oppose the erroneous view, that on account of the small resistance of mortar the strength of cut stone cannot be fully utilized. Certainly the resistance of concrete or poorly coursed rubble masonry depends almost entirely on the n nature of the mortar, but it is otherwise in brick masonry. Experiments in the technical experiment station at Berlin (Report of same in 1884, p. 80) gave for cubes 3 months old made of the same bricks in lime and cement mortars the slightly differing resistances of 44 and 63 kil, while the resistance of the kinds of mortar employed exhibited the great difference of 12.5 to 211 kil. For a longer time of hardening and thicker walls we judge that the difference in the masonry would be yet smaller. But for large ashlars and uniformly thin joints the influence of the mortar must almost enterely disappear, it being assumed that the latter has the otherwise required properties, that first consist in that it is pressed into the hollows without being entirely pressed out of the separate parts of the joints by the existing compression. Under these conditions would it be almost the same whether cement, lime, lead, chalk or powdered loam were employed, that selected good stones might fearlessly be used w with a loading up to 1/10 or at least 1/20 of the ultimate resistance to crushing, and thereby build considerably safer in any case, than if one now generally finds it well to stress easily rusting iron to 1/4 or even 1/3 its resistance (with connections that in part are no more trustworthy than mortar joints). Men have already made sufficiently bad experiments in the fall of numerous bridges.

We see from all this, that our buildings of weak materials and with disadvantageous distribution of the masses are restricted to very small heights, and that on the other hand by using good materials, the limits are drawn less by the resistance than by practical reasons of other kinds.

Stability against wind pressure.

Magnitude of wind pressure.

The stability of a body increases with its weight and its basal area, but on the contrary diminishes with the increase of the surface presented to the wind. Therefore it is important especially for the upper parts, which one seeks to construct as light as possible, that they be disigned with proper consideratiio of

wind pressure. Farther downward can the distribution of the masses be then made according to the laws previously given. The w wind pressure is greatest where it strikes a surface perpendicularly and is reduced considerably by a greater inclination of the surface, whether in elevation or plan (p 163). Thus the wind pressure against the angle of a square tower, in spite of t the greater diagonal width, is only 0.707 as great as the pressure against the side surface. The pressure against a cylinder is 0.785, that against an octagonal prism is 0.707 as much as the pressure against a perpendicular surface of equal area. S Since in determining these values friction on the surfaces was neglected, it is better to increase them somewhat, especially with large projections on the surfaces.

The magnitude of the wind pressure seldom goes beyond 120 kil per sq. m, but has occasionally been observed at about 200 kil in Europe. Where this concerns the calculation of stresses in roof construction or edge pressures in masonry, men are usually satisfied by assuming 120 kil per sq. m, especially in protected places. This is to be defended in so far that the strength of the material indeed is stressed only in certain limits, thus always retaining a certain safety. If it concerns lofty roofs or walls, it is advisable to increase this vaule under the circumstances to 150 or 180 kil. But quite otherwise are the conditions when the danger of overturning (for example of a wooden or iron tower spire not anchored), where no security exists to be counted upon; here for square structures must be taken at l least 250 kil for surfaces struck at right angles, for round or octagonal towers or spires at least 200 kil for the full vertical section. But if one desires to use smaller values like 120 kil, he must also introduce a certain safety and require that the moment of stability be at least twice the overturning moment.

Stability of towers.

If the stability is investigated by calculation, one must first be convinced that no direct danger of overturning exists (p 137); there one cannot usually be satisfied but must examine f for wood and iron, whether the members with wood support the structure just before the overthrow are sufficiently strong ((example on p 622), and for stone, whether the edge compression does not increase too much. For the last purpose is sought the point of intersection of the resultant pressure with the base

area (p. 140, 166, 336, 377) and then the edge compression is obtained according to p 141 to 145.

If the tower stands on separate very high piers, it may become necessary for these to be calculated particularly for overturning or bending (p 359 and p 169 above), but usually at corresponding heights the piers and even the walls of the tower are so strongly connected together, that the entire tower can be regarded as a connected mass. Then the basal area is regarded as a firmly connected figure, in spite of the fact that in some circumstances it is entirely resolved into separate piers.

To employ formula 5 on p 143, it is necessary to determine the moment of inertia for the ground plan, which is well known to be found for compound areas by addition or subtraction of the moments of inertia of the separate areas, for example for a circular ring, if D and d are the outer and inner diameters; $I = \frac{\pi}{64}(D^4 - d^4)$; for the hollow rectangle with outer sides B and H, inner sides b and h, is likewise $\frac{1}{12}(B H^3 - b h^3)$, etc. The kern of such a hollow figure is larger than that of a solid cross section and is calculated according to formula 4 on p 142. For example for the circular ring it is a circle with a diameter $= \frac{D^2 + d^2}{4 D}$, and for the hollow square is a diagonal square with d diagonal $= \frac{B^2 + b^2}{3 B}$; for the hollow octagon is an octagon with a diagonal $= 0.27 \frac{B^2 + b^2}{B}$. The thinner the thickness of the wall t the larger is the kern; in the limiting case that the wall is infinitely thin, D = d or B = b, consequently the width of the kern is $\frac{D}{2}$ or $\frac{2 B}{3}$ or 0.54 B, i.e., twice as great as for the solid cross section. But that is very favorable, for the resulting compression in such hollow cross sections can be farther from the centre of gravity without too much increasing the edge pressure. Only when the compression in the hollow square with thin walls falls outside the middle 2/3, i.e., approaches the outer 1/6, the edege compression is doubled. But with regard to the increase of the edge pressure by wind or thrust and a vault, one must not fully utilize the permissible stress by its own weight, and a cut stone that can carry 30 kil, according to circumstances, will only be loaded with 20 or 24 kil by its own weight.

Towers with stone spires and internal vaults are to be so heavy that their stability is not endangered by wind, endeed it is usual in them not to increase much even the edge pressure. For towers with thin walls with wooden spires on the contrary the

wind exerts a substantial influence on the determination of the thickness of the walls. Care must be taken for these, that the wall struck by the wind does not bend, or considered as a straight arch does not press out the adjoining walls. Therefore not too thin are also made the walls of the towers without spires and the thrust of vaults.

Stability of spires.

When the masonry masses rapidly diminish upward, the investigation of the stability also extends to the higher plans, but must particularly take place for the spire. As already shown for the example on p 621, anchoring may very easily become necessary for wooden spires, without such spires presenting the full vertical sectional area calculated to resist the wind pressure of 200 kil per sq. m, if for a proportion of height of 2:1 it has a weight of at least 75 kil, or of 3 : 1 of 115 kil, for 4 : 1 of 160 kil, 5 : 1 of 200 kil, and for 6 : 1 of 240 kil p per sq. m of external surface.

For brick spires 1/2 brick thick occurs the danger of overturning with a proportion of height of 5 : 1 to 6 : 1, and the compression passes outside the kern for a 2 1/2 to 3 1/2 fold height; yet with sufficient safety can a spire 1/2 brick thick can be carried to about a fourfold height, if the apex is built solid, and attention is paid to the upper ending (p 597); for very heavy clinkers one can also go to 4 1/2 :1. Spires 1 brick thick permit doubled heights, and therefore do not require farther investigation.

Thrust of spires and vaults of towers.

Thrust of the spire.

If the possible neutralizing of the thrust of the spire by t the tensile resistance of the upper portion of the wall of the tower (p 606) is neglected, then must the wall be sufficiently strong to resist the thrust. The abutment is investigated for a square tower by taking an angle, thus 1/4 of the tower, or 1/8 for the octagon. If the abutment descends vertically, then must it have at top sufficient thickness or rather sufficient weight to quickly change the oblique force of the spore against the abutment into a steeper direction. On the contrary if this gradually extends outward or buttresses project from them, which are offseted downward, the mass of the abutment can be considerably reduced, indeed the more battering is its outer surface.

The limit would be for the tower walls to be inclined externally and internally to form continuations of the surfaces of the spire. The investigation of the abutment by calculation or graphically can present no difficulty, according to what is stated on abutments of vaults (p 122 to 153).

Thrust of vaults.

Since for vaults that occur in the interiors of towers, where very little thrust occurs at the angles (Fig. 366), and there the thickness of the abutments as shown by the Tables on p 150 to 152, even for vaults of infinite height, if the masonry be not crushed under its own weight, need not be excessively great, there is no reason for not placing the vaults in the upper part of the tower. The thicknesses of the buttresses given in the Tables mentioned could then be considerably reduced, when greater upper loads occur, but then by inclined position or even by corbelling the walls inward it is always easily possible to keep the line of support everywhere in the middle of the supporting parts without great cross sections of the masonry. To strive f for this and then by considering the wind pressure to increase the wall masses downward according to the principle of the increase of the load (p 624), those are the points to be kept in mind in designing towers. Very high towers can be built vern economically, but one can also waste masses of masonry in a very inexcusable way.

X. DECORATIVE PAINTING.

1. The colored Decoration of the Interior. (Note).

Note. Pages 629 to 637 are unchanged from the preceding edition.

Painting of certain parts.

Even in the last centuries and down to the present time have been made endeavors to change the original condition of Gothic churches by whitewashing or other ingenious methods, yet certain works in different regions remained in such preservation before such improvement, that from the principles according to which the middle ages proceeded in regard to coloring may at least partially be recognized. But a study of those principles is the more necessary, since on the point in question views are more widely divergent than on many others, and in each case it is just as difficult as essential to become freed from the last remains of modern habits.

We have frequently been engaged in the restoration of mediaeval churcher, in which the internal coloring was also to be restored, and in some cases have neither had the power or strength to avoid all the concessions to modern taste exacted from us. But we have thereby made the experiment, that only those works could in any way satisfy not us alone, but also the directors and thus the people, where the old was followed with all possible accuracy, and that in nearly all cases the concessions demanded were regretted by those who had required them. But we have had the experience on other works, in which it had been found well to depart from mediaeval types.

Plastering and whitewash.

The question of painting is connected with that of plastering or of whitewash. The last must occur everywhere that the material at command and the mode of execution thereby compelled makes it impossible to obtain even surfaces, and the simplest case of a coating thus requires a limewash, or where it is to create the ground for a richer decoration.

In both cases is the principle applicable, that the plastering as well as the coating must be an actual improvement. On rough walls of rubble it can be applied in its simplest form, while on a better material, first on such that makes it possible to secure even surfaces, the coating is only allowable with a view of a certain development of luxury, therefore requiring a richer treatment. Hence where only the window jambs, angles, mouldings

and the vault ribs are made of cut stone and the walls are of rubble, in the simplest case only the latter are plastered and colored, and the plastering adjoins the edges of the ashlars p projecting by the thickness of the plastering, which again remain uncolored, and where means permit, on the plastering will be painted even certain figure representations in entirely unsymmetrical positions. The latter result from the circumstance that such pictures are but seldom contained in the original plan, but arise from special courses or from vowed gifts..

Painting of keystones and compartments.

Likewise the limewashed surfaces of the compartments of rubble adjoin the ribs made of cut stone. Since now in the vaults the keystones already are emphasized by richer ornamentation in sculpture, it is next at their greater distance from the eye to increase the effect of that ornamentation by color, this increasing their recognition as well as their splendor thereby. As a rule is there adorned not merely the sculpture of the lower surface but also the moulding bordering the edge of the keystone by gold and bright colors, and the same treatment is continued for a piece as the vault ribs and then cut off by radial bands. (Fig. 1, colored plate 147). The cause of this extension is not alone with the view of ensuring a wider field for the development of color, but also that it was first of all to find a suitable termination of this splendor of color on the member, which would not have resulted from the simple junction of the mouldings of the ribs left in the natural color of the stone to the richly painted keystone. In the church at Frankenberg all surfaces of walls and piers and further the capitals and ribs are left in their original dark stone color, but the keystones are painted in the mode indicated and are gilded, and an especially happy effect results because this splendor of color is carried by the ribs contrasting with the white compartments. Without this contrast, and particularly where the painting of the keystones differs but little in color from the rest and lighter parts rise from dark parts, will many modern restorations show how to produce a heavy and burdening impression.

In contrast to the plastered compartments the French mode of execution of the same in cut rubble described on p 109 permits an open appearance by its regular jointing. No less is this possible by a construction of the compartments in brickwork, and

indeed the effect gains life by the alternation of the color of the bricks with the stone of the ribs. In the arcades of the p palace of justice of Liege otherwise belonging to the Renaissance, the compartments are built with not the usual direction of the joints, but by the most varied interlacing of them are formed the most ornamental patterns, in a manner similar to the construction of the half timber work of the wooden houses of the peasants in the so-called old land near Homburg.

The effect of the compartments may even be increased by different colors of bricks, either by the alternation with glazed courses or by richer motives. But in every case is necessary a correct execution of the masonry of the compartment, the joints must extend through according to a system once adopted, and no lost courses may occur therein.

Painting of the capitals.

The next addition to the method of treatment before indicated then consists in a colored execution of the capital, which must extend to the mouldings of the abacus and astragal. Here are first possible two systems. The first would consist in this, t that only the ground of the bell should be more strongly distinguished from the foliage, generally by the decoration by color. The other would add thereto a further characterization of the ornamental details by varied coloring. According to the first would the ornament be entirely painted white or gilded and the bell would be colored dark (Fig. 7 on colored plate), or naturalism already makes itself felt by a green color of the ornament or by a dark green ground.

According to the second system would only similar parts be colored alike. Thus there results one color from the front sides of leaves, a second from the edge and back; the third from the stem, the fourth from the berries or flowers, and the fifth from the bell.

It is here self-evident that gold and even the original color of the material may participate as colors. An example of this kind from the church in Volksmarsen is shown by Fig. 5 of the colored plate.

But further a diversity not yet indicated in the ornament may first be produced by the coloring. Fig. 6 from the church in Wetter.

Painting of vault ribs.

The next step in advance consists in the entire coloring of the

vault ribs, yet where that special accenting of the keystones and adjacent parts of the ribs mentioned above can be retained, so that these are separated by richer painting and form glowing colors from the extension of the ribs.

As a general rule for the coloring of the latter may be applied, that the general effect must be either lighter or darker than that of the surfaces of the compartments, thus lighter with compartments of bricks not plastered, darker for limewashed compartments. This is especially true of the principal member of the ribs, this of the so-called pear-rib of the earlier, the flat hollows according to the later mouldings.

Then we have also here either a uniform coloring of the entire rib or a separation of the different mouldings of it by colors. Fig. 2 of the colored place gives an example of the former from the church in Wetter, and in regard to the latter, there can be extended to it the ground principle of heraldry, that c color can only adjoin metal, that never different colors of equal intensity, but only different tones of the same color may adjoin each other. Further the following principles are applied.

1. that the colors do not oppose the effect of the shadows, that in deep hollow be separated by light from a member like a round that receives much light.

2. That to obtain a bold effect the aid of absolute light, t thus of white or gold, and even that a decided dark, black or dark brown , is just as necessary as dark outlines and leads in glass painting, as well as transparent or white and yellow colors.

3. That the intensity of light or shade is in inverse proportion to the area of the space occupied. Thus a little round bears pure white or gold, a little bevel oh hollow pure black, while for those large and pointed rounds, Figs. 8 and 9 of the colored plate, as for larger hollows, both light and darg require s softening, which may either be by reducing the tone or by a pattern

Reducing the tone is not so much by the addition of black and white as by the addition of another color, so that light becomes yellowish, greenish, reddish white, dark becomes dark slaty blue, dark reddish brown, greenish black.

The pattern substitutes alternation of colors or tones for the same colors in mixture. Therefore in the simplest case it is f found by radiating or inclined bands of different colors, for example of brown and white, green and white, black and yellow,

etc., so that also on that pointed round either the same colors abut against each other or are placed diagonally. They can further consist of triangles, cubes, scales, or bands, or panels enclosed by the different colors may be found for finer drawings. But such patterns must always be simple to be recognized, and before all must all imitation of relief be avoided.

Contrast of color is sometimes strengtnened by black, lines separating bands, which are especially necessary if a color adjoins white. Such an example is shown by the pattern in three colors from S. Peter in Louvain. (Fig. 8 of colored plate.).

Bands may either be formed by a single color,or by several t tones of it and these tones then adjoin in straight lines or a are indented or intersect each other like flames. It is preferable there to separate the shaded bands by a single color or be formed of two strongly contrasting colors. For example if we assume green shaded bands, thhes are to be separated by a dark brown or white, or a white bordered red, brown or dark blue, or a black bordered yellow. Thus sometimes alternate shadings in several colors with such bands. Fig. 9 of the colored plate exhibits an example of the kind from the church in Volksmarsen.

What concerns the placing of the colors on the different members of the ribs is, that these are not always chosen with regard to a heightening of the contrast, but at least for richer mouldings, are usually formed by adjusted groups of them. Thus in Fig. 10 of the colored plate from the castle chapel at Marburg, a transition from the red flat to the white round is formed by the yellow, contrary to which the white round increases the separation between red and blue.

But further pure and gleaming colors areechiefly taken for c certain prominent points like keystones, while for all large areas are preferred reduced or mixed colors.

Especially for the red is indeed exceptionally employed pure vermilion, where the highest magnificence prevails, while its ordinary tone is darker and more like madded (burnt ochre, see below). If then time and dust can injure it, we still frequently have ornamental interior structures like tabernacles, where the original tone was not pure vermilion. Such a dark red tending to brown generally forms the local tone on those little internal architectural works, and it is then brightened by gold and blue, white or by green and white.

The original tone of blue is hard to recognize as a rule. In general it is determined that it must be lighter than the red. For this reason the artificial ultramarine cannot well be employed, which in its pure condition is too dark, but mixed with white becomes muddy. A shining blue is best represented by pure smalt. But an entirely different character has dark blue, which as in Fig. 6 of the colored plate may even tend to gray.

Likewise green varies much, sometimes shining and sometimes softened, in the first case represented by Schweinfurt green, in the latter by different mixtures of gold ochre with so-called green cinnabar.

Bands beside the ribs.

The effect of the ribs may further be heightened by a pattern band adjoining them and painted on the compartment, or be a simple band from which rise painted leaves, Fig. 11 of the colored plate, from the vestibule of S. Peter Jr. in Strasburg. The last motive recalls the crockets, and like them it is sometimes replaced by a comblike ornament, Fig. 12 from a painting in the c church at Wetter dating from the beginning of the 16 th century. From those separate leaves represented in Fig. 11 we then pass to the lower angle between the ribs and laso lying from the keystone on the surfaces of the compartments, soon treated more naturally,andsoon in the later plant and foliage forms in the style, to which we must return later below.

Painting the rounds and arcades.

From the painting of the vault ribs we further pass to that of the rounds. What has just been said of the larger members of the ribs is increasingly true of the always larger rounds, i.e., these either require simple and light tones, or a continuous pattern, which then on account of the lesser distance from the eye is to be executed here in a far richer manner than there. Striking examples of this kind are shown by certain French works in restoration, such as that at S. denis, of the S. Chapelle at Paris, and also of certain choir chapels in the cathedral of Amiens, Beauvais and S. Quentin, on which is seen the development of magnificence in generally the highest degree. It would partly lead too far and would be partly superfluous to go farther into the details of these works, especially since the publication of the S. Chapelle is well known generally, and those that have the luck to execute a portion of such a work would still

do well to make their studies at the place.

According to a painting of the rounds at least on the richer works, where the window occupies the full width of the bay, only the plain surfaces of the piers between the rounds and the ground of the arcades found below the windows remain. The latter in the S. Chapelle are covered by a painted blue tapestry w with gold ornaments, as then generally a tapestry pattern above without the folds there given is most suitable for this. In a chapel of the cathedral of Meaux is found a richer arrangement belonging to about the 15 th century. Likewise here a red tapestry pattern forms the ground, on which are painted a crucifix with Maria anf John at the sides, the Host above it and the chalice beneath are painted in the natural colors, so that the Host is at the apex of the arch. Beneath the chalice is then found a blue shield of arms with three white roses enclosed by green twigs, and below are two figures kneeling at prayer desks, the latter with the clothing of the figures terminating the entire representation at bottom.

The mode of treatment of the plain surfaces of the piers coincides with that around for the general painting of the interior, and in the simplest case consists of a rectangular pattern.

General painting of the interior.

What then concerns a general painting of the interior, those of the compartments, surfaces of walls and piers, there have come to us three different modes of this, but which naturally admit of endless variety.

First mode of treatment.

The first is chiefly found in the province of upper Hesse, t thus in the church at Wetter, the castle chapel at Merburg, and was found in the church of S. Elisabeth at Marburg before the restoration, and must be regarded as the original, belongong to the end of the 13 th or the beginning of the 14 th centuries, since it appeared on the two former works under the second one belonging to the end of the 15 th or beginning of the 16 th century.

This consists of a red local tone, which is tolerably intense in Wetter, and on which is painted a pattern imitating in white lines the jointing of regular masonry in courses about 22 to 23 cm high.

At the middle of each triangle of the compartments and enclo-

enclosed by the ribs is then found varied stars inclosed by circles, one of which is represented by Fig. 22 of the colored plate. The vault ribs are there colored with strong yellow ochre, the rounds in the dividing arches are white, the flat surfaces yellow and the hollows are dark reddish brown. In the transverse aisle the ribs are accompanied by narrow bands lying on the surfaces of the components with dark red leaves on a white ground. All surfaces of walls and piers are treated like the surfaces of the compartments, yet only the larger surfaces of the gable walls of the transepts are at both sides of the windows with two stars, or rosettes like those just described, but richer and larger, painted in different richer patterns. The window mullions are colored dark reddish brown and lighted by white lines and dots, while in the angles of the window jambs are found white stones toothed into the red surface of the wall (Fig. 15).

By these different details are given indications, according to which the entire mode of treatment is in itself very simple, but can be devecoped to greater richness. Thus first by a general placing of that band accompanying the ribs on the compartments, either white or very dark, the stars, rosettes or smaller pranches painted on the flat surfaces of the ribs and arch members, and further by the formation of panels with white grounds in the lower angles, between the ribs as well as first on the keystones with ornaments painted in the dark ground color, as also by the use of some motive on certain parts of the surface of the wall, or even by white ornaments painted at the same places on the red ground. To this was added even a richer treatment of the window jambs and angles, either in the style of the band accompanying the ribs, or by foliage executed with black outlines. To this was also added a rich treatment of, the keystones and capitals executed in gold aod pure colors, which also remained red and white in Wetter, as well as the arrangement of painted arched friezes below the windows, which must be kept entirely simple, without by any meaas similating an effect in relief.

The second system of treatment by color differs from the former only in that the coloring is reversed, for particularly the ground is in a subdued white or in a light stone color, and the lines thereon are kept in a dark reddish brown. At the east side of the rood scheen in the monastery church at Haina a small portion of the plain wall was treated accordingly, so that the sep-

separate stones inclosed by the red lines stand vertically, but with a second line of the same color inside each of them, and in the middle was painted a rosette. In France a similar mode of treamtent is more commonly executed and in part is still recher. An example of this kind from the hall in Angers is found in Verdier. Likewise here are found those isolated ornaments, and there the squaring of the arches is treated with a certain freedom, while the separate stones of the vault are rounded at top. Just on such details is to be laid especial weight, like the vertical position of the ashlars at the rood screen in Haina, the rosettes in them and the isolated ornaments, since these exclude the idea of an intended imitation of actual ashlar work, which latter was effected by different means and is to be regarded rather as a peculiarity of the modern architectural style. This squared painting in opposition to all such means of deception very simply forms a surface pattern, that at most may be blamed as a lack of invention, but which appears to the untrained eye just as it reallv is.

We note here, that this extended use of such an effective motive of isolated ornaments may yet lead to misuse. At least we recall having seen an otherwise correct new church in Soissons in the forms of the transition style, whose interior is painted in the given manner, yet concerning those ornaments not much good is to be shown.

Third method of treatment.

The third mode of treatment consists in a further development of the motive already mentioned above, of plants and foliage painted in natural colors on the whitened surfaces of the compartments, and in an extension of these to the wall surfaces. As such examples we mention:- the choir vaults of the church of S. Elisabeth at Marburg, the later paintings of the castle chapel at Marburg, and the church in Wetter, the monastery church of Breitenau near Cassel, the Liebfrauen church in Treves and the church S. Jacques in Liege.

On the surfaces of the compartments are first found these ornaments, soon more isolated in the manner already indicated on p 633, soon entirely extending over the surfaces, as in the choir at Marburg and the transverse aisle at Wetter, also sometimes intermingled with figure subjects as in Breitenau, where on the choir vaults are found the images if the Holy Trinity, of

the Holy Virgin and of S. Benedict and S. Catherine, but in the middle square are found the symbols of the evangelists inside the given arabesques.

As a rule the stems in the latter are yellowish brown, the l leaves are a bright green and different flowers are painted in other colors, blue, yellow, red and white, yet the latter are sparingly used so that green predominates and its contrast with white determines the effect. In Wetter and Breitenau black or brown outlines are but seldom used, where for crealness they w necessary, briefly where color adjoins color, but not to separate the latter from the white ground. On the contrary in Marburg and likewise in Liege the entire drawing is outlined in black, and indeed in the first place in such a defective manner, that one might almost recognize in it a later addition.

In Wetter the original red painting and the gilding of the relief ornament of the keystone on a dark red ground remained, a and only the mouldings as well as the adjacent parts of the ribs are in various colors without gold, indeed principally in a mode harmonizing with the painting of the compartments, thus painted green, yellow, white, black, etc. Fig. 4 if the colored plate gives an example of this kind.

Similar scholl work, only in larger proportions, was also found on the surfaces of the walls, so that on both sides of the jambs grew shooting stems or stalks from bunches of leaves, ending below in roots and crossing above the windows in arches.

If the attention of men had been attracted to these paintings several decades since, at the time when recognized archaeologists still adhered to the theory of the origin of the Gothic style from the leafy roof of the sacred grove, and even a statue of Ermin von Steinbach was made (indeed only in plaster), as he constructed the pointed arch of two pieces of wickerwork like a basketmaker, perhaps this would have been seen as a proof of that theory, an indication of the profoundest basis of Gothic art expressed in a written cipher.

As we aleeady mentioned on p 630 the simple whitewashing of the suffaces of the walls, each of the modes of treatment explained above also reached its highest ornamentation in certain a actual wall paintings placed even unsymmetrically on suitable places. Thus there is found in the choir at Wetter over the choir stalls the picutre of the Holy Virgin and the Child filling

the entire width of the bay, beneath this being the foundresses of the monastery, Almudis and Digmudis, and there are found vestiges of a contemporary copy of the same picture at reduced scale on one of the crossing piers. In the next bay are then the shields of arms of the elector of Mayence and of Hesse.

The painting of the vaults in the Liebfrauen church at Treves substantially differs from those described above. Here the ground is covered by a yellowish green tone and on this is produced an ashlar pattern by white joint lines. The ribs and keystones are then painted in strong colors and from the latter extends brownish red ornament on the surfaces of the compartments (Fig. 3 of colored plate), and the lower angles between the ribs are painted with white scrollwork with colored flowers. (We shall not omit, that we discovered vestiges of green color on certain scrolls).

We have already designated above the coating of the surfaces of the compartments with a brilliant blue with gold stars scattered over it as corresponding to the highest development of magnificence, that however prescribed a similar splendor of color also for the ribs, rounds, etc., in brief for the parts of the church.

On the French examples mentioned above the treatment of the latter is so bold, that the general effect is still harmonious in spite of the almost too dark tone of the ultramarine. In certain German restorations like the church of S. Stephen at Mayence and the Liebfrauen church in Worms, where the means might fail for a splendid treatment of the whole, the great surfaces partly made it more difficult, and then the pure blue is dulled by the addition of white, so that the golden stars on it appear almost like brass. For this pure smalt would therefore be most suitable.

Meanwhile also in other respects the not very successful Gothic church of S. Eugene in Paris has the surfaces of the compartments coated with yellow, with red stars placed on them, as we have also already found similar experiments on small mediaeval works.

Thus the interior of the wall tabernacle at Wetter is painted in a light seagreen tone with blue stars painted thereon. If then already the original reference to the firmament can be scarcely observed, and the star form is to be regarded only as a

flat pattern, yet it is only one of the simplest and therefore of the most easily employed kinds.

For these varied kinds of experiments of mediaeval polychromy is that new procedure farthest removed, by which for 30 years the whitewashing up to that time was suppressed with the view of putting an end to the monotony thereby produced, and at the same time avoiding the injurious effect of the ground tone on the eyes. This consists in the use of different slightly contrasting yellowish, reddish, bluish and grayish airy tones on the different parts and in its highest splendor rises to gilding certain members or edges, which is naturally entirely without effect in contrast to those broken tones. Particularly common are there the milky blue vaults, the piers, ribs, jambs, etc. With chamois or grayish stone colors, the wall surfaces being painted a softened peach juice, and thus such a dull effect is produced, which by the so-called cultured is usually termed friendly, and that by building officials is sometimes designated as restoring that of the building materials. Most suited to dilettanteism by its indecisiveness, this presents the advantage, that each of the church fathers belonging to the cultured class without consulting an architect could independently give the n necessary directions to the limewasher, and then might enjoy the mild charm of his production. At the present time it is especially favored by certain rationalistic ultras among ecclesiastical and secular officials, who already perceive Catholicism in every decided color. (Note).

Note. Since the preceding words were written, there has been much improvement, the understanding of the old painting has penetrated into extended circles, and many colored works strictly executed in the old sense have originated on German soil. Likewise vestiges of the lod paintings, that indeed everywhere slumber beneath the later whitewash are meantime brought to light in great number. They prove the preceding statements so far, that we hold it to be right to print the latter verbatim in the old form, and to give the most necessary explanations in the succeeding Chapter on the Technics of Painting.

2. Technics of Painting in the middle ages.

Adhesives and colors.

The technics of the painting of the middle ages is naturally based on the traditions of antiquity, that were inherited in

Italy but more in the Byzantine empire. Pliny and Vitruvius, as well as many paintings remaining especially at Pompeii give us information of the skill of the Romans and Greeks. For their mural paintings they appear almost without exception to have employed a well developed fresco method. (Donner, Remaining antique mural Paintings in Regard to Technics). Besides there was also known to them a tempera painting, (Egg and water or fig milk, etc., as adhesive) and an encaustic painting. According to Pliny the latter was not used for walls; the wax colors employed in it appear to have been thickly spread on a ground of wood, etc., with a spatula and then heated, which is unnecessary for our modern fluid wax colors.

Documents concerning mediaeval painting.

In the middle ages the technics were diversified, and there were added oil painting and the preparation of varnishes from vegetable gums melted in oil, etc., and besides was developed the previously well known distemper painting. Besides the art works remaining documentary traditions afford evidence of the methods of painting employed.

The following writings are prominent.

1. Theophilus, priest. Schedula diversarum artium.(see below).

2. Recipes of the monk Dionysius in Handbuch der Malerei from Mt. Athos. German translation by Godehard Schäfer. Treves. 1855. Written in 13 th century with additions until 16 th century.

3. Heraclius. Original text and German translation by Albert Ilg in Quellenschriften für Kunstgeschichte etc., by R. Eitelberger von Edelberg. Vienna. Vol. 4. The date of origin, 11 th to 13 th century, is in dispute.

4. Cennino Cennini. Treatise on painting, published by Albert Ilg in Quellenschriften, vol. 1. Cennino belongs to the school of Giotto and lived at the end of the 14 th century.

Less importance has Petrus of S. Audemar, De coloribus faciendis liber, about 1300, treatise of Alcherius about 1400; writings of anonymous Muratori and Anonymous Bernese (the latter only concerning the preparation of egg albumen, see Appendix to Quellenschriften, etc., Vol. 7.

The most important of these writings is that of Theophilus, who probably lived as monk Rüger in a north German monastery, and describes in the clearest manner not onln painting but also the making of glass and metal works. Copies of the Schedula are

preserved that partly extend back in the 13 th and even the 12th centuries. They are very well edited by Albert Ilg in Quellenschriften, etc. Vol. 7, Vienna. (The added german translation is not entirely satisfactory in places, as for example the expression "illuminare" used for placing the lights is always given as unintelligible.

Painting of books.

Painting on parchment or of books, which may be placed first, is principally a tempera process. The colors are laid with egg albumen, that previously in order that it may not make a wrinkle, is strained through a cloth or better is beaten to foam and must then again be clarified; water is added to it as needed. Beaten egg yolks can also be used, but water and then egg albumen must be added to that it does not scale off.

All colors except white lead, red lead and carmine, that require egg albumen, can also be fixed with gum, i.e., a solution of a vegetable gum (cherry, plum and also resin from needel-leaved trees) in warm water, and also gum arabic was known.

Spanish green, which was employed instead of "Salzgrün (see below) for books, was not fixed with egg albumen, but according to various sources with wine (Theophilus), vinegar, urine or also gum or egg yolk (Cennino). "Folium" (see below) was fixed by urine or egg albumen, and after drying it was painted with folium or carmine with egg albumen (Theophilus, Chap. 40). Gold b bronze or silver was laid on a ground of red lead, vermilion a and egg white or directly on the parchment with gum, a size made of isinglass, leather, eelskin, etc., or also alum, oxgall, etc., was applied and later polished with a tooth or with bloodstone. (Theophilus, Chaps. 29 to 38).

Panel painting in tempera or oil.

Panel painting for the painting of altar panels, doors, ceiling panels, vessels of wood and allied materials with or without a covering of leather or linen is to be considered, and was previously a tempera painting, as just described. Under the designation of tempera painting is best included painting with egg, guml plant gums and allied materials such as honey, milk, beer, etc. Egg, especially in the later time, was mostly thinned with vinegar instead of water, and even with some oil.

Panels were of separate boards well joined together and then glued with strong cement of curd and caustic lime, on this was

cemented leather or linen, then a painting ground of chalk or calcined gypsum with size (boiled from hides or deerskin) was applied several times and then rubbed smooth with equisetum. On this came the color. The chalk ground could also be laid directly on the wood, which especially occurred on curved surfaces. Gold in panel painting and also in mural painting was laid as gold leaf on egg white in one or more layers and was then polished or even painted over.

Oil painting is a species of panel painting, that already was invented very early and probably in Germany, from whence other peoples obtained linseed oil (see Donner, Anmerk. p. 28 to 29). The colors were ground on otone under linseed oil and then often applied with a drying in the sun for several days for each coat (Theophilus, Chap. 20). Finally was applied a varnish made by boiling 2 parts of linseed oil and 1 part gum (Theophilus, Chap. 21). The defect in oil painting was the slow drying, and therefore in rapid work it was replaced by painting uith liquid resin or a solution of gum, which was likewise coated with the varnish above.

Mural painting is most important for us and was in fresco or painting with lime colors, that under some circumstances had t the aid of the tempera process. Colors with size appear to have come less in question.

Fresco painting.

True fresco is well known to be painted with water colors on the fresh plastering, which with a moderate thickness must be only one day old, which requires carrying on the work step by step. The drawing is then sketched lightly on the wall and is then painted; by more accurate work a previously prepared cartoon is placed on the plastering and the outlines are indented with the point. Yet it is not excluded that also without using the cartoon the principal outlines are scratched in to fix them better. Sometimes even surfaces seem to have been sunken deeper, as on the outside of the tympanum of an arcade of the cloister of the cathedral at Stendal, the plastering in the tympanum is enclosed by a triangular band (like that drawn in Fig. 1502 d), whose panels are alternately sunk somewhat and still retain vestiges of red color. A similar arrangement of the plastering is executed for the painting in a very happy at the recently built church of the holy cross in Berlin.

Those wall surfaces were plastered in the interior and also on the exterior, which could not be shown on account of a too irregular appeaaance; neatly cut stones and the structural members remained without plaster, for arcades and window arches m men were accustomed to leave without pastter, but on the jambs the middle strip was to be covered by plaster, when it was not to be made of cut stone on account of louvres. In contrast to the layers of 5 to 8 cm thick of the Romans, the plastering in the middle ages was only so thick as required to conceal the i irregularities. The masonry to be plastesed was not usually recessed below the adjacent parts of the same surface remaining without it, and the plastering rather projected for its small thickness (about 1/2 cm) and was beveled at the edges.

Simplified lime painting.

If the painting is to be executed at once, this is done on t the fresh plastering,(See above), but if it is to be done later, then one is aided by a much used and simpler procedure, that is well established. It is sufficiently important to give here verbatim, what Theophilus says of it in Chap. 15 (See Latin text on p. 640 of Vol. II).

The same is more briefly given at the end of Chap. 16; "all colors placed on the wall under others are to be mixed with lime on account of solidity. Under blue "menesh" and green is placed red lead' under vermilion red ochre; beneath ochre and leaves,the same colors mixed with lime."

From this it proceeds that the colors are mixed with milk of lime, and are applied to the previously mointened wall; but such colors that do not bear mixing with lime so well, are laid afterwards by the tempera process on an already dry wall under color.

For capitals and cut stone members the lime colors and even gold are frequently placed directly on the stone, and this also occurs for wall surfaces. But generally after wetting unplastered walls, men first coat them with simple milk of lime and then apply the other fresco colors very quickly on this limewash. On this white ground are found in paintengs from the 13 th to 15 th centuries also without the gray or brown undercoats given by Theophilus, that azure, copper green and vermilion are applied directly, whether freshly on the lime, or after its drying in the manner described by Theophilus with egg yolk and water, is hard to determine. Moreover these three colors also under the

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The same is more briefly given at the end of Chap. 16; "all colors placed on the wall under others are to be mixed with lime on account of solidity. Under blue "menesh" and green is placed red lead; under vermilion red ochre; beneath ochre and leaves,the same colors mixed with lime."

From this it proceeds that the colors are mixed with milk of lime, and are applied to the previously mointened wall; but such colors that do not bear mixing with lime so well, are laid afterwards by the tempera process on an already dry wall under color.

For capitals and cut stone members the lime colors and even gold are frequently placed directly on the stone, and this also occurs for wall surfaces. But generally after wetting unplastered walls, men first coat them with simple milk of lime and then apply the other fresco colors very quickly on this limewash. On this white ground are found in paintengs from the 13 th to 15 th centuries also without the gray or brown undercoats given by Theophilus, that azure, copper green and vermilion are applied directly, whether freshly on the lime, or after its drying in the manner described by Theophilus with egg yolk and water, is hard to determine. Moreover these three colors also under the

limewashes of later centuries, have kept badly, and the less s suitable colors for the technics of fresco are destroyed. (It is certainly stated for cobalt, that the lime makes it somewhat flatter. Vermilion darkens gradually in the air, yet apparently less with lime than with oil.

Colors suitable for lime painting.

The proper fresco or lime colors, that were approved in antiquity and the middle ages are the following five.

1. Milk of lime (slaked lime and water) was utilized as a white color, as a color for makink the other colors lighter and as an adhesive.

2. Ochre.(iron oxyhydrate mixed with clay) occurs in nature in different tones of yellow.

3. Burnt or red ochre,(iron oxide with more or less mixture) occurs in nature or is obtained from the preceding by heating, which was usual in the middle ages, and was described by Theophilus in Chap. 3. By an adjacent conflagration paintings with y yellow ochre are sometimes burned red. Our English red, iron red, Indian red and caput mortuum are similar products, but the old red was generally clearer and brighter than the two last mentioned.

4. Black from charcoal or soot.

5. Green earth (silicate colored by ferrous oxide, terre verde in Cennino), that is known today as Veronese earth, **mountain** green and stone green, having a broken grayish green tone. To be mentioned here is the Prasinus of Theophilus, that according to Chap. 2 approaches the green and black colors, is not ground on the stone, but is strained through cloth under water, and appears to be very useful as green on a fresh wall. Heraclius (Chap. 37) also indicates a color obtained from mallows with vinegar or wine, which he names earth green es suitable for mural painting.

There are further the following colors previously mentioned. Vermilion, that can even be mixed with lime, and the making of which from sulphur and mercury Theophilus describes in Chap. 41, an animated copper green (yet not Spanish green, see above), the preparation of which is described in Chap. 42 as green salt, a and blue. The latter was mostly copper blue (German blue, Azuro della magna in Cennino), rarely cobalt blue and the very valuable genuine ultra marine (powdered lapis lazuli).

There further appears to be conditionally allowed the purplish color folium, of which three kinds are distinguished by Theophi-

Theophilus in Chap. 40 (red, purple and sapphire) the first of which is made of urine, calcined ashes and caustic lime, the o others are the same without line; they are especially employed in illuminations in books, and according to other statements a are for this purpose fixed with eggs. A color very frequently mentioned by Theophilus is "menesh", which was a broken blue and according to the before mentioned citation was likewise used w with lime colors. The dark sap green was not brought into direct contact with lime, gold pigment and white lead are designated as not to be used for lime pain ing. Red lead according to Cennino becomes dark on the wall, with oil fades with white lead. Theophilus gives as a flesh color determined for tempera in Chap 1, white lead, litharge and vermilion, and that for red parts according to Chap. 4 is composed of some red lead with more vermilion. For mural painting he mixes flesh with lime, o ochre and vermilion (Chap. 15). Perhaps there is a mistake in the mixture of flesh tints (white lead, carmine, etc..), that cause why in old paintings the faces have become entirely white. On the mural paintings in the cathedral of Riga (about 1300) t the colors of the skin have not only bleached under the later plastering, but have so far disappeared, that they do not retain the painted outlines, and the same is the case for parts of the garments apparently painted with like colors. Very particularly are most organic colors, among which are indigo and a carmine already not permanent in light, are destroyed by lime.

Light and shade, interchange of colors.

Relief treatment of the early period.

The procedure in painting was the following. After scratching in or sketching the outlines on the ground, the principal flat tones were laid beside each other and on these were placed darker and on the other side lighter tones for the shades. The first were obtained by mixing in darker colors, the latter by the addition of lighter colors or of white to the first ground tone. Then the tones were ever laid narrower, until the deepest shade was a dark line of the same color as that with which the outlines were drawn. On the other hand the highest light also mostly extended to a light line that with a light ground tone increased to pure white, but only on darker tones only came to ochre with or without the addition of white, as well as to cobalt blue, g green, flesh red (burnt ochre and white). In Byzantine and Early

Romanesque times men shaded quite in relief according to traditions of antiquity, but still in a conventional way. Theophilus describes in Chaps. 14 to 16 very fully for clothing, other objects and rainbows, and in Chaps. 1 to 13 the very careful treatment of flesh. In this time for all round parts, such as the limbs of men, folds of clothing, trunks of trees, towers, clods of earth and scrolls in ornament, the lights were laid at the middle and then were a series of 4 to 6 or even 12 steps down to the outline color at the edge, and sometimes then went from white through yellow and red or blue, etc., to black; the ground color first laid underneath was then somewhat darker, according to Theophilus it was the 7 th with 12 tones, the 4 th for 6, en the 3 rd place for 5. For 4 or 3 tones tne pure color was not the ground tone, but a somewhat lighter step was chosen and on this was laid only one shade tone to the outline. The old paintings prove this.

For objects not round, that it was not desired to leave in o one color, they placed the light at one edge and the dark shade at the other. Thus were shaded also the leaves of Romanesque ornament as indicated in Fig. 1492.

Flatter treatment in middle and later times.

The excessively strong shading in relief is reduced in the t transitional time and makes in the Gothic time a flat painting with moderately strong indication of the shades and lights or indeed also without these. In the last case the painting consists only of uniform tones and outlines, whereby is obtained a very quiet and noble effect and an arrangement of the surface.

An example that the first transition from Romanesque to Gothic modes of treatment very beautifully illustrates, is presented by the painting in the choir square of the cathedral at Brunswick, a portion of which is represented in Figs. 1491 to 1491 b. The ashlars beneath are yellow ochre (apparently changed to light gray, which is elsewhere found for ochre, for example on garments in the cathedral at Riga, where the lights are spared out, the joints being white with brownish red lines at each side. The draperies above are alternately blue, red, green and yellow, the under surfaces visiblae at the lower edge always have the color of the adjacent tapestry. On the ground tone of the drapery lies only a shade tone and a light, (on Fig. 1491 the light lines are dotted) and then come the dark brown outlines, which

are also drawn in the depths of the folds is lines 5 mm wide. In the Gothic time the folds are mostly left entirely without shades, they are indicated in a conventional way by stiff lines, and between each two hollows is placed beneath the point of suspension a fold with a sharp edge drawn as hanging vertically.

In the preceding case the drapery only has an upper decorated edge, and the bottom edge is just marked by a border or fringe. The entire surface usually receives a pattern as shown by Figs. 1503 to 1506.

The tapestry in Brunswick is fastened beneath a blue shaded bar. In a similar manner red and yellow rounds shaded in relief extend above and below the foliage frieze, Fig. 1491 a. The lights of the round are no longer as originally at the middle, but are nearer one edge and are entirely or nearly white. The foliage band has a dark blue ground, the middle leaves are flesh r red, the half leaves are alternately green and blue, the lower trefoil leaves are light violet and the upper ones are yellow. The dark brown outlines are 2 to 3 mm wide and are accompanied by a very effective white line scarcely 2 mm wide (Fig. 1481 a). Stepped tones as in Fig. 1492 are already omitted, only the ribs are broadly placed in a dark color near the ground tone and have at the middle a sharp brown line. Some colors have faded under the later whitewash, but otherwise the ornament shows a refinement in the graduation of the colors and drawing, which is scarcely surpassed by painted ornament in any other style. The treatment of the foliage in relief is abandoned, but a salutary play of the stepped colors is retained.

Treatment of the painted foliage.

Besides the shaded foliage there also occurs in the Romanesque time monochrome foliage, both light on dark ground as well as dark on light ground, and it then assumes a more general character (Figs. 1502 k, 1498, 1493, the latter from the Frankenberg church,at Goslar being reddish brown on a light ground). Gothic foliage is mostly of a single color with dark outlines and ribs. (Figs. 1494 a, 1495). Thereby in the simplest cases were obtained three different colors, one for the leaves (for example green), the second for the scrolls and outlines (for example reddish b brown), and the third for the ground (white, but also blue, violet, dark green, gold, etc.). Greater diversity of colors could be obtained by the occurrence of flowers, berries and accessories,

but still more effectively by varied coloring of the different leaves; thus are distributed on the same scroll light green, dark green, blue, yellowish brown and red leaves.

Another means of securing an animated alternation of colors as a substitute for the earlier shading consists in placing two colors beside each other, for example green and red for the two halves of the lobes of the leaf or of entire leaves (Fig. 1494 b, c). In Fig. 1495 from the church of S. Nicolas at Wiemar the leaves are monochrome, but the branches of grapes are divided between red and green, the leaves and branches have black outlines; the main scrolls are red and the smaller ones are green w without outlines; there the ground of the figures wixed with t the scrolls ascending the high piers as ornaments are formed by a white limewash laid directly on the uneven bricks. In the late time the alternation of two colors often continues regularly through leaves and scrolls as in Fig. 1496, that represents a part of the painting of the vaults of a chapel of the church of S. Nicolai at Juterbogk. Here red and green are contrasted, on other examples are black and green. Black and unbroken yellow ochre generally associate well with the green of Late Gothic scrolls, that combined with great flowers and even figures extend over walls and surfaces of compartments, frequently haveing a rather hard effect in contrast to the earlier foliage. The g ground of these ornaments is mostly white, yet there also occur colored grounds, es in the chapel mentioned at Juterbogk beside white compartments, thev are light green with a darg green monochrome ornament.

Softer is the effect of Late Gothic spiral scrollwork in the style of Fig. 1497, it has passed into the Renaissance and was long valued for the covering of the helmets of shields of arms, and frequently occurs also carved on woodwork from the 15 th into the 17 th century. The upper and under surfaces of twisted leaves have different colors, for example green and red or green and blue, besides the colors toware the points of the leaves too frequently pass into another tone, as from light green into dark green or into light brown or red.

Changes in two colors.

The alternation of two equal colors is a motive greatly extended during the middle and late Gothic in heraldry, continuous ornament, in the painting of mouldings and also on a large scale

in the general architecture of interiors, it was possible with small means to obtain a very effective play of color, to which in interiors the concurrence of colored windows led. In a more modest form occurred such a change in all architectural styles. It commenced with repeating two colors rhythmically, as in Figs. 1502 and 1489. Elsewhere already appears in Fig. 1500 and 1501 from the varicolored chapel at Brandenberg an alternation of the ground (red and gray or red and green under the white ornament). But very peculiar is the effect when the colors shift as in Fig. 1499 from the churhc of S. Nicolai at Wiemar, where red and green not only alternate in the halves of the terminal ornament, but are placed on the springings of the ribs and their accompanying scrolls. Men have frequently carried it so far that entire areas of compartments or parts of the walls have been executed with alternation in colors, that for example a compartment with white ornament on red ground alternates with one having red ornament on white ground.

Colors of geometrical ornaments.

No other art section of ancient and modern times has understood how with equally simple means to make possible a satisfactory colored treatment, as the middle ages by its geometrical ornament. With two or three or even with a single earth color added to lime white, an interior was treated with comparative r richness and always harmoniously by means of the simplicity of colors.

Red ochre alone.

The most important color was burnt ochre. It exhibits when p pure or mixed with a little lime a strong and quiet red, that sometimes passes into brown, but more commonly is so fiery, that an untrained eye sees in it a mixture of vermilion and carmine. (In the works of restoration in the cathedral at Riga it was found difficult to find a modern iron oxide of equal brightness). With more milk of lime red ochre gives pleasing rosy tones. With this simple color in different grades and with white may indeed an architectural part be decorated, or even in entire interior; Figs. 15 and 16 as well as Fig. 14 on the colored plate will allow this to plainly appear.

Red ochre and black.

If a second color be added, whether yellow ochre or black, t there is often a great diversity of tones. A beautiful example

for a painting with two colors, red and black, is presented by the cloister at Riga built at the beginning of the 13 th century (Figs. 1480 to 1485).

Besides the white with the aid of burnt ochre produces a full red and a lighter flesh red (hatched vertically or black in the sketches) and with soot or charcoal black are formed two gray tones (hatched horizontally), the lighter of which mixed with much lime gives a quiet stone gray, that on the contrary the darker is a dark slate gray, and the latter has an expressed t tendency to blue, always resulting from a mixture of black and lime. On the Figs. it may be noted, that Fig. 1480 represents a cross arch, Figs. 1481 and 1482 are the crossing of two round or polygonal ribs, and Figs. 1483 to 1485 are the round extending around the openings of the arcade.

An entirely similar character is borne by the undersides of the cross arches from the variegated chapel at Brandenberg given in Figs. 1486 and 1487, which belong to the original painting. Placing red and gray tones beside each other is very common during early and middle Gothic, and with gray tones not infrequently occurs pure black, as on the recently painted columns of t the chapter hall at Walkenried, on which the colors are distributed about according to the mode of Fig. 1489.

Red and yellow ochre.

Still more effective and warmer are the gradations -- and also in the mextures in the given cases of the two colors; yellow a and red ochres. Paintings executed with only these two colors and white are especially found in the transition time and often in Early Gothic. On the colored plate, Figs. 2, 7, 12 and 14 c chiefly or exclusively exhibit these colors, and Viollet-le-Duc also gives beautiful examples. (Dict. Vol. VII, p. 83 to 89).

The preceding colors and earth green.

The same occurrence of the three colors, yellow, red and gray or black is also certainly as complete, and there is also added the more rarely employed earth green, very good in those tones that can represent green. Moreover also ochre and black has a rather greenish tone; since further dark gray inclines to blue, one does not miss the green and blue colors in the use of only the three principal colors.

Outlines.

Paintings with these simple earth colors are always very quiet

and harmonious, and it is scarcely possible to form with them a glaring composition, therefore they do not need also a separation by outlines, which in fact are almost never employed with them.

In regard to the outlines and the lines drawn elsewhere on t the surface it may be stated, that in the early time and also frequently in the middle Gothic, men with refined feeling mixed the color tone of the lines as a darker stage of the corresponding ground tone as Theophilus prescribed. Later appear more uniformly colored lines of dark brown (brown ochre and black) or blacker color.

Rich colors and gold.

An entirely different charcater is assumed by painting, when there occur the animated colors, vermilion red, copper green and azure or cobalt blue, and eventually other tones. It is then only necessary to add the gleaming gold, or as in the chapel of S. Katherine and the cross chapel of castle Karlstein, even precious stones and glass bits underlaid by gold to develop the greatest splendor conceivable. That the gold would be imperatively required by animated blue as Viollet-le-Duc asserts, we m might not emphasize in such decided manner, with reference to many examples.

That this rich treatment is restricted to preferred points or can be extended over the entire interior is more fully stated in the preceding Chapter, and to add to the examples there given is unfortunately impossible with the space otherwise exceeded (Note), and we must be satisfied though unwillingly, by compressing in two plates a number of sketches in Schematic representations.

Note. Therefore reference is made to the first not extensive but for the time very well worthy of consideration, the literature on ornamental painting. 1. Viollet-le-Duc. Dict. Art. Peinture. 2. A. Schäfer. Gotische Wandmalerei zu Marburg. Deut. Bauz. 1878. p. 324. Same, gotische Zimmermalerei aus Fritzlar, Zeit.f. Bauw. 1881. 3. Essenwein, Martinikirche zu Köln, Organ f. christ. Kunst; same, cathedral at Braunschweig. 4. Steinbrecht, Hochschloss zu Marienburg, Cent d. Bauw. 1885. Moreover are scattered statements in inventories and architectura monuments. Further works with plates. Aus'm Weerth, Wandmalerei des Mittelalters in den Rheinlanden. Ungewitter, Ornamentik (unfinished). Mural pain-

paintings in S. Chapelle at Paris, Mural Paintings of Notre Dame at Paris, etc.

Optacal illusions.

To the plates are also added Figs. 1488 to 1490, that show g geometrical motives on shafts of columns and of rounds. For these it should not be omitted, that the rope pattern (Fig. 1489, bottom) can easily produce an optical illusion of an oblique position of the column, and this in some circumstances can occur on a great chevron pattern, and the latter can further cause an apparent diminution of the column upward or downward according to the point of sight. Great patterns like that of Fig. 1487, which frequenlty occur, may produce enlargements or reductions or wavy outlines. patterns like Fig. 1490 are little or not at all affected by such illusions (also see on p. 587). Such illusions are not serious in themselves, but on the contrary they serve to animate and to arouse a too rigid quiet; they are likewise not foreign to Greek architecture, where it is only on many kinds of frets, especially an unexpected wave line (running dog), and there are even found well known twisted Doric columns. Moreover it is entirely required to properly use this powerful means, since a frivolous or unknown play with them instead of animation may produce the impression of unrest or even of anxiety, gust as does the new painting of certain churches.

Window enclosures, bands and borders.

With the sketch in Fig. 1498, which represents the enclosure of a window of the church of S. Katherine only remains in small fragments at Riga, let the note be joined, that very often such scrolls extend on door and window arches, that are formed like the scrolls accompanying the ribs in Figs. 1490 and Fig. 11 of the colored plate, and frequently terminate above the vertex of the arch in richer leaf or flower crownings.

Wall patterns.

Fig. 1502 exhibits borders and bands of different periods, t that are found in most varied repetition on members of vaults, cornices, painted tapestries, jambs, vessels, etc. The peculiar border in Fig. 1502 a very frequently occurred in Byzantine b buildings, and larries its origin back to borders of clothing with precious stones. Likewise the wall pattern in Fig. 1503 already occurs in Early Christian times (baptistery of Orthodox, Ravenna). Stars, rosettes and crosses as shown in the most dif-

different forms in Figs. 1504 and 1505 are never enclosed by l lines, but often extend independently on the surface; the same is true of the richer forms in Fig. 1506.

Figure ornament.

Fig. 1507 is a portion of the genealogical tree of Christ discovered in the former vestibule of Riga cathedral, which represents an axample for the interweaving of ornament and figures, which frequently occurs in Romanesque buildings in a far more complex manner, and has found its place especially under broad dividing arches. Likewise on continued friezes and entire surfaces of walls in the Early and late periods men and animals are not rarely inserted in foliage. Unfortunately the figure painting must remain excluded from our consideration.

Painting on the exterior.

In conclusion reference may be made to this, that also on the external surfaces of buildings occurred paintings, that are like those of the interiors; they are employed to characterize preferred parts like the portals or passages, or to elevate an entire wall surface, which does not appear in naked form. Likewise on brick buildings occurs painting, aside from glazing, it finds there its particular place on the plastered friezes and blind arches, and is still often preserved.

Mosaic pictures are rare in Germany, among which the relief figure of S. Maria on the castle chapel at Marienburg occupies the most prominent place, but are naturally the most monumental expression of external painting.

Mistakes in restorations.

In the restoration of mediaeval buildings the ornamental painting is usually entirely neglected or spoiled, and the figure painting is also very badly treated. Might men then finally desist from repairing as quickly as possible the uncovered paintings, instead of simply restorong them somewhat in the injured and lacking parts, or where the locality permits, to leave them entirely untouched. If however all must be painted anew, one m might seek means to copy faithfully the discovered painting on linen, stretching this over the old. At least then the old painting is not irrecoverably lost for research, which is the case by repainting by the best artists, since posterity can never have proof of the conscientiousness of the work. In every case men should never touch a painting without examining its technics

and copying in very detailed form in its condition as found.

CONCLUSION. (Unchanged in this edition).

The most acute perception of the conditions to be fulfilled, the given proportions and the peculiarities of the materials, the endeavor ever to attain the greatest aims with the smallest means, but first of all the conscientious fear of any untruth in the development of form and the avoidance thereby required of all substatutes, are characteristic peculiarities of Gothic construction. Even the frequently occurring conpeftion according to the worst works of Late Gothic partakes of these, and sins only by a certain overloading, a splitting of hairs dangerous to every principal.

In noless measure are those peculiarities also those of Greek architecture, so that the full diversity of the results is even based on the difference in conditions and materials, as well as further in the era and the course of development of Gotnic art, whereby this was placed in condition to develop the results of all preceding art epochs, thus also of those following the Grecian, into its own system.

Herein in the traditional character of Gotnic art, in its thoroughly preserved historicity, lies a second and no less important impulse of it, whereby it differs not so much from the Renaissance and the Rococo as from a certain tendency of modern a aims in art, which proceeds there to the invention of a novel and contemporaneous architectural style by means of an entirely capricious mixture of all preceding on the vehicle of the substitute. Instead of assimilating the principles of the preceding styles, men thus secretly try its results, instead of using the materials belonging to the modern period like cast iron, which possesses really valuable qualities, and using it according to them, seeking to develop a corresponding form, it is employed entirely as an imitative material for the display of a richness foreign to the entire construction, it is cast into shapes entirely contrary to its properties, in brief men seek to attain thereby a free artistic activity, that entirely excludes all capacity of understanding and even all deeper study.

Concerning this free artistic activity, there is now a quite conceivable thing. Whatever a titanic individual may give or has given, according to the preceding and to unite at once the

elements of the earlier into an entirely new whole, and thus m make almost a real fact, it is still the belief, that it belongs in this category to regard every single one as a misfortune. But for all natures planned on a smaller scale, the only way to artistic freedom is only through a careful study of the preceding art periods, to find by conscientious research their structural principles, and therefore since Gothic architecture in a sense represents the conclusion and product of all primary periods of art, first in the study of the latter. May it be in the result in these pages to make easier such endeavors.

The End.

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HISTORY OF ART IN ANTIQUITY

VOLUME VII

HISTORY OF ART IN ANTIQUITY.
Volume VII. Part 1.
Greece of the epic period.
Chapter I.
General Characteristicr of Grecian Civilization after the Do Dorian Invasion until the middle of the eighth century B. C.

I. History.

In the first part of this history of Grecian genius, we have already had occasion to give the names of the principal groups that appeared to the ancients to form the natural divisions of the Grecian race. We have mentioned the Achaians, Ionians , Aeolians and Dorians; we shall frequently have occasion to mention them again as so many families also distinguished from each other by certain peculiarities of temperament and customs, and by differences of the dialects spoken by them. While taking into account the original predispositions of those different groups, in descending the course of the centuries we shall see these shades gradually effaced; but before they have entirely disappeared, the moral unity of the Grecian world, that only one which it ever established, will have found its sensible expression in the name of Hellenes, which is claimed with pride by all that believe they have some right to bear it. We saw th this name originate under the forest of oaks that sheltered the sanctuary of Dodona, and because it responded to the intimate and secret consciousness of ethnic relationship, it gradually extended and ended by being applied to all the elements composing the nation, to those living molecules, that seem at the same time to repel anf to attract each other.

Curious and subtle as it was, the Greek mind attempted to harmonize,two facts that seemed contradictory; on the one hand the ideal unity, whose visible sign was this same name of Hellenes, and on the other, the diversity of fixed characteristics transmitted from generation to generation in those different alliances of tribes and cities. One may relieve himself from embarrassment by a procedure, on which we shall rely for many other applications to the problems of the same order. Of all relations that can exist between men, the simplest is that establishing a bond of consanguinity between persons descended from a common ancestor. Then is imagined an entire genealogy, and

Hellen is invented, who is given as the son of Deucalion, tha t alone by the protection of the gods escaped the destruction of the human race. Hellen thus found himself the father of the entire new mankind, that peopled the land recovered from the deluge, or at least the portion of the earth where wa established the selected race. Ion, Aelos, Acheos and Doros were the sons or grandsons of Hellen. [1]

Note 1.p.2. What proves the slow fabrication of these geneologies are the variations, that they present, according to whether they come from an Attic or a Dorian source. The Attic version assigns to Ion a sort of elder right, which is elsewhere attributed to Doros. Eurip. Ion. 1 - 82, 1591 - 1594; Strabo, VIII. 7. 1. In the geneology proposed by Strabo, he makes no mention of Aeolos.

The conventional character of these combinations, that did not know Homer, is betrayed as soon as one recedes to the most ancient and most sincere forms of the tradition; in fact that assigns an importan part to peoples, that have no place marked in this schema, because they disappeared early, after having taken a great part in increasing the value of the soil and in the creation of the industries necessary:- such as those Cretans who founded in the Archipelago the maritime empire to which the name of Minos has remained attached; such as the Danaians of the Argolis, the Minyans of Orchomenos and the Cadmians of Thebes; also such as the Epeans and the Taphians that the Odyssey places west of the Peloponessus and in the neighboring isles. For a stronger reason the Pelasgians, seen in the distance of the prehistoric ages, as the primitive basis of the aboriginal population, remain outside that classification, like those nameless peoples whose existence is revealed to our curiosity, on the coasts of Asia Minor and in the islands, by the remains of entirely primitive tools preserved to us in the tombs

If from the time of Herodotus and of Thycydides there was but a single Greek community, which was not attached to one of the four stocks into which were divided the descendants of Hellen, that is the result of a twofold work, which operated in the s same things by the effect of the struggle for life, and what was later undertaken by the poets and early historians. On the one hand, favored by circumstances, certain tribes are found to plaw the first parts; their dialects were fixed in beautiful

works and had the chance to become literary languages; their myths had escaped from the narrow limits of the district where they were born; they had borne very far the worship and images of the gods, that were their heros. The states founded by those privileged tribes had subordinated the heterogeneous elements, found in the entire extent of the circle in which their influence was exerted. Around Miletus and Ephesus were soon only Ionians, although the coast extending from the mouth of the Hermos and that of the Meander had received immigrants from all points of the European continent. The work of reduction thus commenced continued by the thoughtful effort of all those, who applied themselves to placing in order all the confused multiplicity of facts, and of piercing wider avenues through the forest of traditions; when they found on their path a city not yet classified, they arranged to add it to one of those groups, by connecting them to others by threads ingeniously crosse, myths that primitively had no relation between them.

From the Dorian invasion of the first olympiads, i.e., about from the year 1000 t the year 750, one is still far from the epoch when those spontaneous groupings and those systematic views had simplified the appearance of the Grecian world. That appearance must be very complex in the age succeeding the fall of the Achaian kingdoms; but nothing is more obscure than the history of those two or three centuries. When the historians of the classic age attempted to reestablish for that period the sequence of facts, they could only invoke oral tradition, and that is always subject to suspicion. Of written documents dating from that time, such as lists of priests and of eponymous magistrates, laws and treaties, nothing exists. At earliest about the year 800 men commenced to apply the letters of the Phoenician alphabet to the sounds of the Greek language, and many years were necessary from the point a which was made this first attempt, for the marvellous invention to be diffused in the rest of Greece, for the practice of writing to enter into current use. If one sets aside some proper names incised in the sides of the rocks in the necropolises of Thera, we have no inscriptions, that appear to date beyond the 7 th century, and the Grecian cities must scarcely have preserved authentic monuments that could have a higher antiquity.

From that period date the two great poems, in which is summ-

summarized for posterity the creative work of epic genius. On e might then be tempted to believe, that he has a chance of finding in the iliad and the Odyssey indications vainly sought elsewhere relating to the subject of the number and the extent of the principal states of Greece, of their relative importance and of the relations sustained between them, and the most notable events of which they had been the scene. These hopes are not realized by the epics. Doubtless in episodes like the list of the ships, there is more than one fact useful to collect; but as the ancients had already recognized, these lists suffered retouchings on several occasions, that permit their evidence to be invoked only with extreme reserve. For what there is of the tale, it is difficult to find any allusions to events of the c contemporary personages. Nothing recalls the Dorian invasion, the movements and displacements for which it gave the signal, the new conditions in which it placed Greek society. One cannot be surprised by the affairs of the men of the present do not appeal to the imagination; that is even but moderately interested in the past of yesterday, a past whose witnesses still live or have but just died. For free play, there must be r recoil. That is the case especially for the epic period. Every great epic poem is the testament of a world that has completed its work, of a vanished world. What is reflected in the Homeric epic, as understood since Schliemann has exhumed Troy, Tyrins and Mycenae, is the Achaian world with the fame of its powerful sovereigns, the memory of their warlike prowess, of cities girdled by high walls in which they led a royal life, of the treasures that they hoarded in their castles. In the distant and glorious past the Aedes seek their heros, just as the troubadours of the 11 th and 12 th centuries in the full feudal regime demand theirs from the impressions left in the memory of the peoples, of the grandeur and splendor of the Carlovingian empire. The song of Roland and all the heroic poems of the same cycle explain to us the Iliad and the Odyssey.

What complicates the task of the historian is, that for this period nothing is to be expected from the aid of archaeology; excavations are far from providing supplementary information as rich as for the preceding age. Among all those commotions art seems to have retrograded rather than advanced; in any case it became much less original and less fertile. One or two centuries

must have passed before Greece recovered its equilibrium, after having been profoundly disturbed by the abrupt invasion of the armed bands, that came from the high mountains of the North to throw themselves into the Peloponessus. To maintain themselves in their conquest, the chiefs of these armies first of all counted on the strength of their arms. Their feeling was later expressed by a celebrated verse of the poet Alcman, concerning that Sparta which had no fortified walls when it was in full decadence: --

"Men with hearts are the surast rampart of a city."

The Dorians scorned to shut themselves up behind walls. They despised luxury; the painter no longer had a palace to cover with his frescos, and the ceramist had seen his patrons restrict themselves, whose commands aroused him to vary his subjects. They no longer required the sculptor to chisel funerary steles, and beautiful vases of gold and silver decorated by human figures; no more proud symbols were to be patiently engraved in metal, jasper and sardonyx, for the bezels of princely rings. All these artists, for whom opportunities of exerting themselves became more rare, forgot their vocations; then so to speak, they left nothing that can profit the curiosity of the historian. There are no longer found here those statuettes and reliefs, that come in such great numbers from the tombs of Amyclea and of Mycenae, all those works of sculpture, which if they do not give the names and histories of the chiefs to whom they belonged, at least inform us what homage was rendered to the gods, what vestments were worn by men and women, what game they pursued in the chase, and what equipment they carried to the combat. These representations of figures, this vision of the actual life, is what is lacking to us for the society, which succeeds what we have called primitive or of Mycenaean Greece.

Not on the epic period can one count to fill this gap. Doubtless it did not develop and assume form till after the migration, among the Aeolians and the Ionians of Asia Minor, around Smyrna and at Chios; but if it was on the eastern shores of t the Egean sea, that the poets created the figures of Trojan heros, of Priam, Hector, Paris and Sarpedon, it was to continental Greece that belonged all the Greek heros, Agamemnon, Menelaus, Nestor, Achilles, Ajax and Ulysses. In the Peloponnessus and in Thessaly commenced to celebrate their prowess, and

in Thessaly men commenced to celebrate their prowess, and in t those tales of war and adventure, that lengthen and become complicated, they have always retained the arms, vestments and attitudes lent to them by the first Aedes, in spite of all the r retouchings suffered by the original themes. This was a sort of local color, that by a natural and just feeling of the needs of poetry, the poets endeavored to retain faithfully; it charmed by taking from home the imaginations of their auditors. In time there is introduced in these tales more of a trait borrowed f from later usages, in arms and costume, in all the additions of the generations that have seen the work completed by the formation of the two great poems to which is attached the name of Homer; but the old basi has no less remained, even in the decorations, if it be not always easy to distinguish, what the poet received from his distant predecessors and what he has taken from the scenes of his own time.

Oral tradition, as it is transmitted in the Grecian cities, then remains the only source from which could be derived in the course of the succeeding age the elegiacs and the lyrics, that in their poetry, entirely circumstantial and actual, make such frequent allusions to the fast, then a little later the early historians, who strove to group in a general representation all the statements, that they succeeded in collecting, by requesting from each city and each Grecian tribe the memories, that they had retained of their most ancient princes, the migrations that had led into the district occupied by them, and the struggles that they had sustained against their neighbors. There could not fail to be many gaps in the information so collected, and on the other hand the testimonies of all these witnesses could not always agree. Herodotus transmits to us the results of his inquiries, but is frequently the first to point out that there are contradictions in the words of those questioned by him, on the subject of the same event, but in different cities.

If the fact of the Dorian invasion does not appear to afford a doubt, if the study of the monuments of art tends to confirm the veracity of the traditions, that Greece had preserved on this subject, we know almost nothing of the conditions in which was carried out the occupation of the country. We are ignorant of the incidents of the struggle and how long it lasted. What

one divines is that the invaders, as well as the vanquished, who by necessity in their turn became conquerors, employed long years in settling and establishing themselves in the new homes, that they no longer must leave; this was a clow work of adaptation and settlement, whose incidents varied much according to the places and the times.

Even in the districts of the Peloponessus into which the Dorians cut their way at the point of the sword, their ascendency was not made to be felt everywhere with the same energy. In many places, the immigrants were either less numerous than in other districts, or the ancient inhabitants remaining in the country had resisted better, and affairs continued to follow nearly the same course as in the past. There is a certain city like Corinth, which seems to have been scarcely affected; life did not fail to resume there its former charm, the character t that it had from the site, or that was developed from its entire past. The Ahgolis was the first province invaded, the lot of honor assigned to the eldest of the descendants of Hercules; yet also there the primitive people quickly raised their heads; There is reason to believe that the old Achaian cities, like Tiryns and Mycenae, preserved their independence, very near t the Dorians grouped at Argos, around Larissa, the high citadel dominating the entire plain. The Dorian city in particular in the peninsula was Sparta, that the masters of Laconia founded on the bank of the Eurotas,above Amyclea, which had until then been the largest city in the valley. There were manifested more clearly than elsewhere the qualities and propensities, that one mentions as the distinctive mark of the Dorian genius, a brilliant courage, always subject to a strong discipline, the love of order and rule, the docility with which the individual subjected and sacrificed himself to the State, and solidity of an intelligence firmly attached to tradition, mistrusted novelties and but slightly aspired to progress, tendencies that about the end of the 9 th century found their expression in what are called the laws of Lycurgus. Crete saw established analogous institutionsin those of its cities, such as Cydonia, Cnossos and Lyctos, where the Dorian bands, who were scattered in the island, were sufficiently in force to cause their customs to prevail.

Protected by their mountains, the Arcadians had retained their

freedom. Of all the villages in which they were distributed, only one rose early to the rank of a city, which was Tegea; that by the fertility of its plain acquired sufficient importance to arrest the ambition of Sparta, when that menaced Arcadia. A province that seemed more exposed to the covetousness andthe attacks of its neighbors was Elis, the portion of the Peloponnessus containing the greatest extent of cultivable lands. It was saved by the abilities of the princes of the Achaian and Eolian races, that reigned at Pisa and at Elis; they k knew how to profit by an antique sanctuary of Zeus and of Hera, that passed for having been founded by Pelops on the site later celebrated under the name of Olympia; they instituted there public games, that were frequented by the in abitants of the neighboring districts, and to which men came from increasing distances, as their reputation extended; this was already made before the name of Coroebos came to be inscribed at the head of the list of winners in the foot races. Entire Elis benefited by the prestige of the deities and of the festivals of Olympia; it became a sort of sacred territory, that rarely had to suffer the ravages of war, and the lower valley of the Alpheus, where the piety of believers accumulated votive offerings, as one of the places toward which we shall be most frequently brought in the course of of our researches. On the other side of the gulf of Corinth similar conditions and politics ensured the independence of the little sacerdotal State of Delphi, the religious cap tal of the restricted Hellas, that from the course of the Achelous extends to Thermopylae and even to the point of Attica; the same wealth accumulated as at Olympia.

Since they had extended beyond the excess of their population, the Beo ians applied themselves to increase the value of their soil, and that task was facilitated for them by the labors already executed by their predecessors, the oriental colonists of the Minyens of Orchomenos. There in the bosom of unsedentary a and laborious community, was to be born the poetry of Hesiod about the end of the 9 th century. That poetry represents the first effort of reflection, the first attempt made by the Greek mind to judge of life, to condense in the form of proverbs and precepts the results of experience, the fruit of a wisdom that already had its bitterness, however young it might be.

The neighboring province of Attica seems later; it is not yet

ready to take the brillian initiative reserved by the future; bu already that future was preparing. The invasions had not conquered Attica; they had obtained over it no effect other than to supply its people the aid of choice elements, Ionians expelled from Peloponnessus by the Dorian spears, great Achaian and Eolian families, who brought with them the memories of their power and of their warlike prowess, sung by the poets. Thanks to these reinforcements, Attica prespered in spite of t the poor soil, by the stubborn labor of those cultivating it. What was lacking to them, they easily obtained from outside; the peninsula terminated by cape Sunium extends well among t the Cyclades and is nearer Asia Minor than any other part of the coast of European Greec. The country had only had at first villages, that were founded by men of very varied origin, and lived as strangers to each other; then it had a dozen market t towns that assumed greater importance with their castles where resided the chiefs of the noble families. Between the districts was war for a long time, until the time that peace was established, due to the predominance acquired by the principal market town of the valley of the Cephisus, that under the name of Athens has held such a great place in the history of mankind. It had the advantage of occupying a location best chosen, at equal distances from the strait of Euboea and the frontier of Megara; but what gave it particular strengthwas an isolated rock, that its height and the steepness of its sides destined to bear a fortress that should command the entire plain. A wall had been built only around the plateau, that one reached only by stairways and ramps easily defended. The princes of the family of Erechtheus, who had fixed their residence there, felt themselves impregnable there; their supremacy ended in being so well recognized, that all the inhabitants of Attica were accustomed to turn their eyes toward the city formed at the foot of that citadel to regard as their political and religious capital. Each district had retained its particular religion, some of which like that of Eleusis, were adopted by the native people; but the great national festival was that celebrated in the capital in honor of Athena, in that Acropolis where the goddess occupied the first rank beside the other gods, who also had their altars there, like Zeus the protector of the city, and like Poseidon, dear to the entire Ionian race. The Panathenaea

was the visible and solemn consecration of that unity, which was slowly constituted, never to be broken henceforth. To a hero by the name of Theseus, tradition attributed the honor of having created that unity; it gave him adventures and exploits in which the marvellous plays such a part, that it is truly difficult to see a historical personage in the Theseus, who by the incessant labor of the poets became the Athenian Hercules, a replica of one of the types dearest to the Grecian imagination. Yet under that growth of fables, one divines an entire series of combats between the petty local dynasties, of victories of the lords of Athens, of affairs ending in the creation of a State in which dominated Ionian blood. This State appeared in very limited dimensions, and yet there was not in the entire Greek world, where was grouped around a single city without a peer by universal consent, a number of men so important, all citizens of the same city, where were their homes, that they either found in the capital itself or on the frontiers of the territory. This was one of the most original characters of the Attic State and one of the secrets of its power.

In Asia Minor was no compact State created by these Ionians, most of whom came from the harbors of Attica. The bands of immigrants had landed, each at its own time, on different parts of the Asian coast, some in Lydian lands and others in Carian lands. There were founded as many distinct cities as there had been bands of immigrants and favorable sites. Even the form of he ground seemed to predestine those cities for a separate existence. The country separa ing them was intersected by deep valleys and by high mountain chains; those at the approach to the shore opened like the fingers of a hand, and ramified in divergent spurs; thus several cities inserted between these a abutments had no easy relations wit their neighbors, except by sea. A federative alliance was established; they had national festivals near a common temple on the promontory of Mycale; they sometimes aided each other, at first to repulse the attacks of the Carians, at the expense of whom these colonies extended their suburbs, and later to resist the king of Lydia and the Persian satraps; but the cohesion was never very strong; each city followed its own course and had its own for unes. Some, like Magnesia of Sipyle and like Ephesus, by the effect of the situation occupied or the special character of their religion,

entertained closer relations with the inhabitants of the interior of the country; others like Phocea and especially Miletus, devoted themselves with enthusiasm to maritime commerce, and only labored to extend and multiply themselves outside by founding numerous agencies scattered over distant countries. Life here was then extremely active and varied. In the contests it wa necessary to support against in order to appropriate for themselves a piece of the territory possessed by the aborigines, minds were hardened, nothing was better to raise them and keep them on the alert than this abrupt entrance into the unknown, than the sudden appearance of the oriental world seen in the background, either at the ends of the valleys descending from the plateau, or on the distant coasts of the Black sea to the sea of Cyprus, that they were greatly emboldened to reconnoitre, and where all was discovery and surprise. Thus one cannot be astonished that such surroundings saw arise the first fruits of Grecian genius that reached maturity; There in the Eolian and Ionian colonies epic poetry had that full and brilliant growth, whose final flowering left for the admiration of posterity two masterpieces, the Iliad and the Odyssey.

2. Religion.

"Hesiod and Homer," says Herodotus, "were the authors of the first theogonies, who assigned to the gods their names, distributed them among honors and functions, and fixed the features of their figures."[1] Herodotus exaggerates; the part of Hesiod a and Home in the development of Grecian mythology is certainly less important than he asserts; but he has reason to recognize in those poems hre most ancient collection of documents, from which one can seek how the Greeks have placed the question of human destiny, of the origin of thangs and of the aim of life. What forms the superior in erest of this poetry is that one finds ther , sometimes implied by means of illusion, sometimes presented under the transparent veil of myth, conceptions very diverse and sometimes contradictory, that are added and s superposed on each other, without excluding each other, and w without the late comers neutralizing those preceding them. The Homeric mythology, it has been said, is faded mythology. In fact, many myths found there evidence the moral preoccupation and labor in reflection, which are already far from the first spontaneity; but under the superficial layer is discovered,

that when one sounds what a geologist terms the most ancient f formation of the earth, the accumulated deposits of the intellectual labors of a long past, metaphorical expressions, whose sense was lost while they still remained in current use, fables that appear fantastic or puerile, gods decayed or dead, rites more or less struck with desuetude. From Homer to Pausanias is far, and this past that never resigned itself to perish, still betrays itself on nearly every page of the book in which the traveler of the second century of our era describes the infinite diversity of the sanctuaries of Greece and of their divine images, where he mentions those local religions, that have not been destroyed by the concurrence in a common religion by the entire nation, and where he stops before the strange and almost formless images, that remain standing on their pedestals, at a few steps from a Hera of Polycletes, of an Athena of Phidias, or of an Aphrodite of Praxiteles.

Note 1.p.11. Herodotus. II. 153.

By connecting all these indications, we shall attempt to comprehend in its entirety the evolution of the Grecian genius, from the confused impressions that it experienced at first before the sight of the universe, until the last term of the fruitful effort of thought, that gave birth to the great gods of hellenic Olympus. One cannot study the history of Greek art without attempting to define the character of this religion, whose dogmas it has expressed with so much power and magnificence, starting from the day when it was no longer emberrassed by the difficulties of execution.

Of all the nations of antiquity, the Grecian with the Egyptian are those that allow the historian to go back farthest in the life of their perceptions and imaginations. Besides, the curiosity of modern science, when it attacks the problem of t the origins of civilization, often finds itself in presence of monuments that leave without reply the most interesting questions, that one may attempt to address to them. It is in vain to turn over in all directions the articles of stone and of bone, that fill the cases of our museums, they tell us nothing, and we shall never learn what names the inhabitants of the caves gave to their gods, and what idea they formed of them. On the contrary in Egypt from those thousands of inscriptions translated for us by the pupils of Champollion, there issues

a voice that has neither its tone nor accent, words whose meaning is still explained by the paintings, that are like illustrations of the hieroglyphic text. Those words, the most ancient ever entrusted to writing, after five or six thousand years have elapsed, have just revealed to us the faiths and hopes of those men of old, of those that according to all appearance were the first to form a civilized society.

Greece has not the same privilege. Writing was only introduced there very late. The oldest monuments of its sculpture, not being explained by inspriptions, tell us nothing of its religion; but for it the Hellenic epoc alone atones for that disadvantage. What that poetry expresses are the ingenuous emotions and naive judgments of an adolescent people, who without having yet forgotten the dreams and the games of its infancy, already feels the ardors of youth, and arouses itself to its noble anxieties of spirit. To fulfil that office, it has at command a language, that thanks to the superiority of its processes of derivation and composition, gives to the image a clearer contour and to the idea more precision, than the Egyptian language could do with its far more elementary mechanism. The Egyptian proscynemes of the Book of the Dead, in spite of the trouble taken by Egyptologists to explain the formulas to us, are far from having the clarity of the Homeric epoch; this causes us to comprehend better what was among the Greeks the notion of the divine, and to what conception corresponded each of those superhuman personages, between which were divided strength and action.

The Grecian mind is further nearer our own than the Egyptian mind, and an uninterrupted tradition of learned culture connects the modern and ancient world. Although the intelligence of a man of the 19 th does not develop in the same conditions as that of a contemporary of Homer, there suffices for him an effort not exceeding his powers to understand the thoughts of the poet. What also aids him in that undertaking is the additional information that he owes to other documents, later but still very worthy of confidence. The lyric and dramatic poets have t taken the myths of the epic, while diversifying them. Among the variants that they introduced, there are some entirely due to their imaginations, while others, though not having been placed in the Iliad, Odyssey and the Theogony, yet also came from that

common fund, the legacy of the first ages, from which Homer d drew. A number of myths of as ancient origin have been preserved by later writers, by the Alexandrine poets, mediocre poets but very erudite, and by those polygraphs, who from the time of the Ptolemies to that of the Antonines and even later applied themselves to making an inventory of the fictions that delighted t the first fathers of their race.

The figured monuments furnish their part of the information. If the painters of vases borrowed their themes from these secondary epics, now lost, that were composed after the Iliad and Odyssey, and were known under the name of Cyclic poems, these poems had not that wise unity of the two masterpieces tha they followed, more easily allowed themselves to be divided into episodes, each of which furnished a subject for a painting. Some information of primary importance is also gathered from the inscriptions, those engraved on tombs, especially those belonging to the archive of temples! One finds there the local gods or at least epithets, surnames of the divinity mentioned by no w writer; these texts are the only ones to make known some religion, whose strange rites they describe, that are faithfully transmitted from generation to generation from a very high aytiquity. Finally it is only till the study of the private and public imitations, that a very vivid light is cast on the birth and progress of the religious sentiment; it is known what results Fustel de Coulanges derived from that examination, in a book whose doctrine is prescribed in all memoirs, what a penetrating analysis he has given of the principles on which rest in the Greco-Roman world the family and then the city, which is only an enlargement of the family. Thus by this mythology of polytheism in which modern science stubbornly sought the primary beliefs of the Hellenic race, he knew how to attain the preceding states of perception and of thought, the truly primitive conceptions.

These conceptions are those that we have attempted to define with regard to Egypt, those commonly designated today by the t term fetichism or animism; that state of mind is what created the first explanation that man gave to himself of the mystery of nature and of life. His first movement everywhere is to represent to himself the world entirely peopled by voluntary forces, capricious and passionate, similar to the force that he

feels acting in his own bosom; he takes himself and projects himself everywhere into the external world. The universe is s seen confusedly in its perpetual appearance, as to him like t those floating masses of vapors, that on the peaks of the Harz return to the traveler his own image, sometimes repeated several times, sometimes diminished or enlarged. In the sun that ascends or which descends to the horizon, and in the lightning that gleams, in the fountain that dispenses around it coolness and fertility, in the tree that opens its leaves to the month of April, in the serpent that flees and rustles the dry plants, in the wild beast that attacks the flocks and the dog that guards them, man seeks and believes that he finds persons, free agents, some of whom are his enemies and the others are his f friends, his benefactors.

It is in the period when all souls are dupes of that illusion, that everywhere is born language, as attested by the considerable part that metaphor plays in it, and that not only in the poets, but also in the most clever prose; in Greece as elsewhere, human speech has assumed its habits and ineffaceable bent in a mental regime that characterized "the flight of our primitive tendency to conceive all external bodies whatever, natural or artificial, as animated by a life essentially analogous to our own, with simple differences of intensity.

Note 1.p.15. Auguste Comte. Cours de philosophie positive. Vol. V. p. 30.

These beliefs have also left their traces in religion. Doubtless this is already no longer what inspired Homer and Hesiod, nor the architects and sculptors of the classical age; but besides that worship by which in magnificent edifices and before statues of gold and ivory, Greece honored her Olympian gods, more humble rites persisted obstinately, worship in which was not displayed the same pomp, but which perhaps had a stronger hold on minds, and to which the Grecian soul remained faithful for long centuries. There was then at first the worship of the dead, the primary foundation of the family and of the city, a mystic bond maintaining their cohesion. Its rites are perpetrated with a singular persistence, in a society whose theoretical ideas for many years have ceased to be in harmony with the hypothesis that implies the entire ceremonial. This hypothesis attributes to the dead, laid in the tomb, a life prolonged while

it is sustained by offerings. Man by this change of condition finds himself invested with a power the more formidable as it is badly defined; this hero or subterranean deity, as he is called, as he is honored or neglected, can cause the happiness or misfortune of his posterity. This living dead, who thus depends on his descendants, and who in return exercises on their terrestrial destiny such a sovereign influence, is the primary and the strongest of all fetiches, the one that it is most important to c nciliate his favor, and whose ange is most to be feared. It is again a fetich in the flame of the domestic hearth, and later that of the public hearth of the city, that flame that must never be extinguished except to be immediately rekindled, that pure and sacred flame on which is poured the libation of oil and fat that feeds its ardor; man addresses his prayer to it; asks from it wealth and health. When he can no longer conceive the divinity otherwise than under the form of man, with a body and a sex, he will personify that flame in the goddess Hestia or Vesta; [1] but he will never have myths of Hestia, as there are myths of Hera or of Aphrodite, and that difference suffices to prove that Hestia, so far as a concrete person, is not a contemporary of the group of great goddesses, daughters or sisters of Zeus, where she was introduced later. This is a delayed creation of the spirit of system. This had blossomed there, where had succeeded without effort that imagination still young and fresh, from which were born the other deities of Olympus; it did not know how to give individual features to the figure charged with representing in its pantheon the beneficent force, that men adored in the fire of the hearth that cooked t the food, and whose heat warmed the family seated around the s stone that supported it, at the centre of the habitation; the statues of the goddess are rare; none of them are ci ed that might be the work of artists of the archaic period. This because the worship of Hestia had retained its entirely primitive character. Not to the daughter of Chronos and Rrea, sung by Hesiod, but to the fire itself the Alcestes of Euripides addressed himself, when before leaving hi home, he desired to recommend to the protection of an all powerful deity the children, that he was going to leave orphans. [2]

Note 1.p.18. Homer frequentl alludes to the sanctity of the hearth (hestia); but he does not recognize Hestia as a divine

personage. The earliest mention of her is made in the Theogony.
Note 2.p.18. Euripides. Alceste. Verses 162 to 169.

The worship of the dead and that of the hearth are not the o only ones, that have retained the imprint, and continued the traditions of these primary beliefs, there are also those found in the homage rendered to the springs, rivers and trees. Then when art had given charming forms to what were called the nymphs of the forests and of the fountains, when it represented t the rivers with the features of robust old men with muddy beards, the head crowned by thick hair pierced by horns, the emblem of strength, the memory was always retained of the time, when as says the poet:-

"Each tree divine
Enclosed its dryad and its young sylvan,
Who shed in silence from his changed skin,
The sap in long drops under the rent bark." [1]

The inscriptions incised on the walls of the grottos where t the living water left the rock, the offerings cast into the basin, where it was heard to gush and murmur, the hair that young men and young girls cut off on the banks of the stream to abandon it to the waves, [2] the sacrifices by which they honored those sacred trees, and the votive offerings that were suspended from their branches, [3] all that dates from the distant period, when the spring, the river or the old oak beneath which shepherds and flocks sought refuge from the ardor of the sun of noon, was for the people of the vicinity a fetich, that those propitiatory gifts would decide not to cease to make the plain green, or to spread there the shade of its branches. Also what was adored in the powerful plant, whose youth was renewed each spring, was a fullness, a superabundance of life, that could pour it out on feeble mortals, whose infirmities were healed at the contact of that flourishing and indestructible health. The tree attracted to itself all the misfortunes of men, and delivered the latter from them. [4] This fetich tree, I have found several times on my way in Greece, Asia Minor and Syria, still surrounded by the same veneration as in the time of the Pelasgians or Hebrew patriarchs, still charged with the same functions. [1] In Bithynia I met with it for the first time. At the summit of a hill toward which ascended the path that our horses followed with slow steps, I perceived from afar an enormous tree, with a grea

trunk, a large and round head. As I approached, its appearance seemed to me more and more singular. Very little verdure, and only in the upper part; lower were spots of yellow and white, red and blue, I asked myself how a tree could bear at once flowers of all colors. I seized the solution of the enigma, when I arrived at the foot of the oak. Those many colored spots were rags attached to the branches, where they replaced the leaves; each of those tatters was a sign and memorial of a fever, when the sick person had come to rid himself of it, to tie to the tree; this was the expression employed. Some years later, I d discovered that the same superstition still existed in France. In a forest where I was hunting, in Champagne, I saw bits of w wool tied around the low branches of an old oak leaning over a fountain, and was told that this was a fairy tree, to which from all the villages around, persons came to ask for healing.?

Note 1.p.17. Fontanes, La foret de Navarre.

Note 2.p.17. Pausanias.VIII.41; Homer. Iliad. XIII.141.

Note 3. See Art. Arbores sacra by de Saglio in Dictionnaire des Antiquites Grecque et Romaines (Paris, Hachette. 4to), and the work of Carl Bötticher (Der Baumcultus der Hellenen, etc. 8vo. Widmanns Berlin). The book is full of facts; what are wanting are general ideas).

Note 4.p.17. It was especially to the laurel, that was attributed in antiquity this virtue of healing, and in what is said to us of the beneficent influence, that i was supposed to exert on the fields where it was planted, one finds the idea by which we explain the service, that one still today demands from the fetich tree. Here are two texts that leave no doub in that respect:-- (Greek quotation from Geoponica. V. 33, 4). (Latin quotation from Pliny. N. H. XVIII. 45).

Note 1.p.18. On the worship of trees among the Hebrews, see Histoire de l'Art. Vol. 1st. p. 379,380.

Note 2.p.18. This was more than 30 years since. It was in a warren located on the territory of Barbonne, a village of the district of Sezanne in the department of the Marne.

The imagination of the fetichist had such power, that it not only lent a soul to the animal and the plant, which approached man by the common attribute of organic life, but even to the inert and cold stone. We have mentioned the place occupied by the worship of betyles or sacred stones in the religions of

Syria and Asia Minor; [3] but this worship was also maintained in Greece, even after that art had peopled the temples with statues. To designate this kind of idols, the Greeks of this time often employed a word of Semitic origin, Baitylia, betyles (idol-stones). Thus in their early relations with the Phoenicians, they had heard these give this name of beit-el ("house of the deity") to the cone of stone that the devout Syrian merchant, when he had unpacked his goods on the shore, hastened to take from the side of his ship and to set up very near t this icprovised bazaar, in honor of his goddess Ashtoreth, who had saved him from the peril of the sea. In the naive admiration that men experienced for those representatives of a superior civilization, they hung on their lips and appropriated t the word; but as for the thing, they knew it well before entering into relations with the Asians. Nothing more natural under the sway of the fetichist conception, than to attach and to entrust thus to the solidity of stone the conservation of a group of those divine energies, whose presence and mysterious action man feels everywhere around him, energies that he is bound to ensure their assistance, under penalty of being their sport and victim, if he does not succeed. Thus the Greek language has for for the naming of objects of this worship, besides the term of foreign origin, a phrase drawn from its own stock; It calls them unhewn stones, argoi lithoi.

Certain of these stones passed for having fallen from heaven, and men have thought to find in this circumstance the explanation of the superstitious respect surrounding them; but it is particularly in Syria and in Asia Minor, that one meets this worship of aeroliths. It does not appear that in Greece men attributed this character to most of the betyles, that in the 2d century B. C. were still exhibited in the old sanctuaries of Beotia, Megaris, Arcadia and of Achaia. Pausanias attributes it only to three stones at Orchomenos. [1] He found at Pharae in Achaia some thirty quadrangular stones, that were regarded as symbols of an equal number of gods; "this is," he says, "because among the Greek peoples at a very ancient time, rough stones took the place of images, that were later multiplied in the places of worship. [2] If men satisfied themselves for centuries with such elementary representation of the divinity, this was not only because the hand of the artist was not yet

sufficiently exercised in modeling clay, stone or wood. The tr true motive of this abstention must be sought in the nature itself of the belief, in the logical consequences of its principle; It is that one cannot fully comprehend until one takes into account the progress that realized the substitution of po polytheism for fetichism, and that one has defined the enfluence, that could not fail to be exerted on the sculpture by the new belief.

Note 1. page 19. Pausanias. IX. 37 - 1.

Note 2. page 19. The same. VII. 22 - 4.

From pure fetichism, the mind of man passes to astrolatry, which is already th result of an effort of reflection and analysis, then to rise to the conception already much more abstract, whose sketch is traced from the time, when he has commenced to suspect the inertia of the material, and of which he fixes more the principal lines as he believes himself more certain of the truth;[1] Then he detaches from the things to which he had arbitrarily attributed them, the highest attributes of being, whose type he had found in himself; but he then detached ther from the external world only to seek another subject, only to transfer them to the invisible agents in which he personifies those superior forces, by which he feels himself dominated, those that limit the duration of his life, and that regulate its course. Those agents he conceives as being endowed with intelligence, sensibility and will, but with an intelligence having a very different scope than that of man, a sensibility more passionate, a will not obliged to take account of the obstacles against which ours strikes at every step. He cannot conceive, without representing them to himself under definite features, the agents that he calls his gods, between which he divides the oversight and direction of the different orders of phenomena, of which the universe is the theatre; each of them has his special function, more or less rigorously determined; the form that will be assigned to it must then be in relation to the special character of the part with which it is invested; one must be able to recognize the personage and name it, by the sole expression of its physiognomy.

Note 1.page 20. We have insisted elsewhere in more detail on the place occupied by astrolatry in the normal development of religious thought. (Histoire de l'Art. Vol. F. p. 42 50.

By this reason polytheism is more apt than any other religious system to favor the development of the arts of design; It imposes on the plastic faculty an effort, that does not require from it fetichism; This is indifferent to the form; the composition and appearance of the body matter little, as soon as they interest the imagination; it animates them and deifies them indistinctly. All this that can be demanded from the artist by the religion founded on this hypothesis is, that in certain cases it offers its assistance in its best to imitat the reality. For example, see the worship of the dead as Egypt practised it. It comprised images, that reproduced as faithfully as possible the features of the deceased, gave consistency to what was termedhis double, and walled within a subterranean chamber of the tomb, served to support the always wavering personality of the phantom.[2] Some of those statues are marvellous in resemblance and truth; but there is nothing that must arouse the spirit of invention. One can say as much of the animal, the tree, the block of stone to which the superstition was particularly attached; If one copies it to have reproductions to increase the number that benefit by its virtues, there is no need to make it more beautiful than nature; the purpose is attained as soon as the copy is an exact reproduction of the original.

Note 2. p. 20. Histoire de l'Art. Vol. 1. p. 180-184.

It is entirely otherwise with the gods of polytheism. The artist is called to distinguish them by the choice and combination of forms used by him to create types, each of which must be the sensible translation of a general idea. These differences he marks by the peculiarities of sex and age, of the shape of the body and the lines of the face. As his hand becomes more skilful, he comes to make all these beings personages more and more definite, in which as in the animal, the secondary characteristics of the organism are strictly subordinated to those personal characteristics, employed by science to constitute the genera and species. Such is the principle that Greek statuary compelled itself to apply, and full success crowned its efforts. Before a fragment of a male torso, the archaeologist will know how to state if i is that of a Zeus, a Hermes, an Apollo or a Bacchus. According to whether the sculptor proposed to himself to represent this or that of these gods, he wi

have given more or less breadth to the shoulders and more or less firmness to the flesh of his marble. There will be powerful muscles, filled with an adult force in full swing; here will one feel the dry and nervous vigor of the ephebe trained in the exercises of the palestra; elsewhere the contour will be more supple; he will even sometimes go so far as to recall the roundness of the body of woman and render the sex almost doubtful. If one then comes to find the head to complete the statue, all will then be in harmony wit the character of the bust, e everything, even the least detail of the face, the freshness of the soft stretched skin, or the wrinkles that furrow the b brow, the hair assembled in great masses, which gives the whole an air of majesty, or short and hard like a fine sod, or again raised in a knot on the top of the skull, and scattered over the neck in soft falling curls, finally the beard, ample and developed on Zeus, Poseidon or Esculapias, while it is not traced on the chins of the immortals, Apollo or Bacchus, that the imagination desired to decorate with the graces of eternal youth.

Centuries of assiduous practice in sculpture are necessary to obtain such precise determination of the divine types by a marvellous harmony of all the refinements of form. Polytheism succeeded better in Greece than elsewhere in this expressing by signs borrowed from the different modes of organic life the ideas, that it had been led to make of invisible beings which it charged with the administration of the various departments of nature. The secret of this superiority is, that it has taken more decidedly the method of only taking the elements of those figures from the traits that characterize the human species. The means that Egypt most commonly employed to give a body to its gods, was to combine the form of the animal with that of man; most frequently it has placed the head of an animal on the shoulders of a man or of a woman.[1] Now however far one goes back in the history of Grecian sculpture, he finds nothing similar. Greece only accepted those combinations in secondary types, most of which were furnished in all pieces by oriental art. Of all these types, some like the sphynx and griffin have played in Greece only the part of motives of ornament; others like the harpy, siren and centaur, whatever their origins, have entered better the current of the mythology

and of the national poetry; but still, these have also remained in the second place. As for the gods properly so called, nothing authorizes me to think that their worshippers saw them with the eyes of the mind under those hybrid featured, or that they represented them thus, when they attempted to model their images. Men have greatly criticised the epithets ox-eyed and g gleaming-eyed, that the Homeric poetry gives to Hera and to Athena;[1] they have pretended to conclude from them, that there had been a time when those goddesses were represented, one with the head of a cow, and the other with that of a screech-owl;[2] but we have vainly sought among the monuments and we have not found one of them, however ancient and rude it might be, that confirms that conjecture, and this is further in contradiction with the entire epic period. None other of the great divinities has for qualification an epithet, that allows this interpretation: one does not see why Athena and Hera alone should have passed through a phase not traversed by their brothers and sist

Note 1.p.22. Histoire de l'Art. Vol. 1. p. 58 - 67.

Note 2.p.22. Schliemann, Ilios, city and country of the Trojans. p. 374-384.

It is true, that men allege the evidence of monuments that we have studied as they merit to be; I desire to speak of Mycenaean intaglios. One sees on certain of these engraved stones and in the remains of frescos monsters, lions with mens arms;[1] unnatural beings, that on a human body have the head of an ass or of a horse;[2] one would then voluntarily be disposed to ask himself if he had not under his eyes the works of a period in which the ancestors of the Greeks themselves had also sought in the joining of heterogeneous forms and in the resulting complication, the means of rendering the idea, that they formed of the divine; but those monsters occupy only a very small place in the repertory of the artists, who engraved those intaglios, and further nothing characterizes them as veritable gods. They seem to belong to the same family as the nymphs of woods and waters, as the satyrs, Pan and Silenus, as all the genii who were vaguely seen among the reeds of fountains and in the depths of thickets, were born and multiplied between the time when pure fetishism reigned, and that when was constituted the polytheistic system. Now like the preceding, this period of transition does not reveal itself directly to the historian.

Its poetry has perished; its en irely rudimentary art was not yet capable of translating into the language of forms the conceptions, that then prevailed in the minds. These only divined the empire that they had long retained in the imagination, t the part that they always preserved in the local religions, the persistence of certain types, which all rejuvenated and embellished as they were by poetry and by the classic arts, no less bearing the marks of their origin. From the Mycenaean age, under the features of man or those of woman, the coastal inhabitants of the Egean sea, in Asia Minor, in the islands of the Hellenic peninsula, appear to have represented their principal divinities; it is the human form that is found everywhere, more or less awkwardly rendered, either in rude statuettes, in which we have recognized idols, or in images to which appears to be addressed the homage of the faithful, where the engraver on stone and the fainter have represented ceremonies of worship, scenes of sacrifice and adoration.[3]

Note 1. p. 23. Histoire de l'Art. Vol. 3. Figs. 555, 556; Vol. VI, p. 856, Fig. 428[16], 431[8].

Note 2.p.23. The same. Vol. VI, p. 885, Fig. 428[8], 432[15], 438. Other intaglios seem to represent monsters of the same sort with bird's claws or lion's paws, the head of a hare or wolf. (Milchhoefer, Anfänge der Kunst, p. 55, 68).

Note 3.p.23. Histoire de l'Art, Vol. VI. p. 852-853, 735-762, 840-844, 890; Figs. 293, 295, 325-354, 425, 428[23], 429, 440.

Then so far as one can judge by the images where the form does not yet give a very clear translation of the idea, it is probable that at Tyrins and at Mycenae were already invoked several divinities of which Homer sang, perhaps Zeus and Rhea, Artemis, Hera and Aphrodite; in any case the Greece of Homer is frankly polytheistic. The gods that it regards as ordainers of the phenomena of the physical and moral world, which lends to them the masculine strength or the graces of woman, it endow them all with marvellous beauty, a beauty that it has derived from all the features of the type of its people, but which, carried to that point of perfection, is never among mortals, but an accident of brief duration and rare exception. This will be an affair for the artists, when matter will obey them with docility, to realize the visions of the poet, to fix them in the images that respond to the attempt of an imagination,

that will have been made compulsory by the brilliant epithets of epic poetry, and by the vivid colors of its paintings.

There is a question that imposes itself here:- why are the Greeks the only ones that went to the end in that path of anthromorphism, in which other peoples stopped halfway; Why alone, instead of seeking in the diversity of specific characters of animals the means of differentiating their gods, they imposed on themselves the more difficult task of arriving at that result only by the fineness of the shades, that served them for distinguishing the different fashions of the bodies and the faces of men; it has been said, that the Greeks first took into account the bad impression produced on the mind by the combination of forms thus borrowed from very different types; they had better taste than the Egyptians and the Aryans. That is a very insufficient solution of the problem. Those mixtures have something displeasing, when they are formed by the simple juxtaposition of incoherent members; but they give happy effects, that spring from the unforeseen contrasts, when a skilful hand has known how to manage the transition from one form to another, so that the entirety thus created may have all the appearance of organic unity. Greece charged herself with furnishing the proof of this by the use that she made of certain artificial t types, notably that of the centaur.

The appearance of a composite form further only allows itself to be judged by the execution. As long as that form only floats before the mind, it remains too evanescent, so that this defect may be sensible, if the parts are not well joined. It is entirely otherwise when this image is solidified in a figure, that presents to the eye the fixity of its outlines. Now when the Greeks assumed to define their gods, that they could not do without giving them a body, sculpture was still in its infancy. If in certain of their works, the goldsmith and the engraver of intaglios sometimes knew how to give life and nobility to the images of the superior animals, such as the goat, lion and bull their success was never complete when they attempted the human figure; they seized its movement, but altered its proportions. This is then not a proof that Grecian taste could take account of the bad effect of those combinations in which other peoples appeared to delight.

It has sometimes been thought to find in the nobility of the

physical type of the Greek race the explanation of this very m marked tendency to anthropomorphism. It has been said, that if the Greeks only thought of representing under other forms than their own the gods that created their thought, this was because the Greeks were beautiful, that they knew and were vain of this; but what people could one cite, who do not admire themselves with the best faith in the world? Those that appear to us ugly and almost deformed find pleasure in looking a themselves in a mirror, and smile at the image that it reflects. We further cannot be surprised that the Egyptians and Assyrians both experienced that feeling. The Egyptian type is elegant and refined, the Assyrian more robust and harder; but both have a grand air. Yet Egypt and Assyria, particularly Egypt, gave to many of their gods and goddesses, instead of the noble or charming faces of the most beautiful of their young men or of the most b beautiful of their women, the heads of the crocodile or hippopotamus, serpent or cat, a lioness or bird of prey.

I the animal element never entered among the Greeks, even for a small part, into the image of Zeus or Apollo, Athena or Aphrodite, such as the poets sketched them before the artists gave them a material consistency, it is from the turn and the quality of the Greek genius that must be demanded the reason of that difference. All childlike as it was still, this genius was henceforth one that must later create philosophy and science. Even in the time when all its thoughts were produced in the form of myth and poetry, it had already carried observation and analysis farther than the Egyptians and the Chaldeans, when they passed through the same phase of their evolution. When it had conceived the idea of those regulating powers, that maintained order in the world, it had seized more strongly than its predecessors the essential character, that distinguishes man from the animal; it had recognized that man is the o only living being that reasons his acts, the only one where reflection precedes action of the will. Once penetrated by this conviction, would he have been justified in seeking elsewhere than in human nature, in some sort multiplied by itself and carried to the sublime, the elements from which he formed the soul and the flesh of his gods?

The epic period in which is summarized all the work of the primitive period, boldly evidences the superior compass and

virtual power, which then distinguished the Hellenic period. In comparison to the wealthy and civilizations already so well equipped in the valleys of the Nile and of the Euphrates, they were almost barbarians, those Achaians and Aeolians for whom had been composed the songs from which came the Homeric poems. Yet the rhythm and language of those poems, the feelings and ideas that the personages express, the arrangement of these tales and these scenes, the sketching of these characteristics, all finally concur in making the Iliad and the Odyssey master-pieces, which in spite of the youthful and sincere naivety that they retain, seem to be much nearer us, and are more easily i intelligible to us, than the monuments of Egyptian and Chaldean letters. If one establishes a comparison between the oriental world and rising Greece, the latter represents from the first a state of intelligence more advanced, and one could almost say more modern. One can then expect to find in Greek art, when f for it sounds the hour of free development, something neither placed there by the Egyptians, Chaldeans, Phoenicians, nor the peoples of Asia Minor, a nobler and purer beauty, the express-ion of the most elevated thoughts.

We shall not attempt to give the history of the principal i deities of the Hellenic pantheon, by asking ourselves for each of them, whether the ancestors of the Greeks brought it with them, when they came to settle in the country to which they gave their name, or indeed if it be a stranger, who by the fa-vor of international relations, has come and is acclimated else-where than its place of origin. To establish, if one can so s speak, the civil status of those divine personages, it is nec-essary to venture on the land of comparative mythology, still far from solid and slippery, to discuss without competency San-scrit etymologies, as well as resemblances pointed out by some and contested by others, between the deities whose power is cel-ebrated by the poets of the Vedas and those sung by Homer. Then it suffices to recall in a general way the results that now a appear acquired for science, in spite of the controversies car-ried on concerning the primitive sense of certain names. Dif-ferences of opinion only concern the deities; men are agreed to recognize that certain gods belong to the common patrimony of the Aryan race, that they were born in the minds of the fa-thers of that race before their sons successively leaving their

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mysterious cradle, separated and scattered from the banks of t the Ganges to those of the Seine and of the Thames. What places these gods out of line and defines them is that everywhere, among the different groups of the ethnic family where one finds them, they bear a name derived from the same root, a name that corresponds to an identical conception. The true type of these gods that may be termed the Aryan gods is that god, who at last among the Greeks and Italiotes assumed early the role of a supreme deity, the Dyaus Pitar of the Hindoos, the Zeus Pater of the Greeks and the Jupiter of the Latins.[1] Other gods appear purely Greek, i.e., that neithe their name not the notion that this name represents are found outside Greece. For example, such is Poseidon, the god of the sea, of that sea which the Aryans did not know before their dispersion. Such also is Apollo; the name that designates him, whose sense further remains obscure, offers not the least analogy with any divine names that the history of religions raised among congenerate peoples, and what is still more significant, this discovers nowhere, neither in India nor in Iran, a figure that by all the character of its physiognomy and by that of its attributions, can be justly compared to the Apollo of Delphi, the sovereign healer of the evils of the body and of the soul, pacificator of consciences, of troubled families and cities, where the sounds of his voice and of his lyre diffused calmness, where the expiatory ceremonies prescribed by his oracle reestablished order and harmony. One has the same impression before Pallas Athena; at first the goddess of the aurora or of the lightning that pierces the cloud and causes the beneficent shower to pour, then goddess of combats where coolness and artifice surpass brute force, she has finally become by a gradual transformation, the inspirer of all useful inventions, the eternal wisdom, the deified intelligence.[1]

Note 1.p.27. James Darmesteter, Le dieu dans la mythologie aryenne. (Essais orientaux. 1883. A. Levy. p. 103 to 133).

Note 1.p.28. As for what concerns each of these divinities, the probable etymology of its name, and the different conceptions to which it responds, one will consult a book in which are summarized the researches of the principal contemporaneous mythologists, the Mythologie de la Grece antique by P. Decharme. (2 nd edition. Garnier. 1886).

Besides these legitimate sons and daughters of Aryan genius, that it brought into the world, some in the distant native land whose memory is lost, and the others later on the shores of the Egean sea, it has its adopted children. The error of Ottfried Muller and of Weloker, of Gerhard, who have cast so much light on Hellenic mythology, has been not to appreciate at their value the influences suffered by the Greek race, from the moment when it entered the circle of the coast peoples of the Mediterranean. It has also been wrong to attribute to religious conceptions the same persistence as to a language, to believe that they would as victoriously resist the influence of the foreign elements. In spite of the attachment that every people bears to its own gods, it is not possible to withdraw these from the influence of outside religions; there is for its beliefs a peril which these will have so much less chance of escaping, as the adjacent people has a civilization more brilliantly developed, and a worship in which images and external pomp play a greater part, a worship that by these means acts more strongly on the sensibility.

We have stated how the Grecians eagerly borrowed from the Semites of Chaldea, their neighbors and subjects, the worship of the goddess Anahit.[2] The maintenance in all its purity of the spiritualistic worship of Ahura-Mazda, the sole god that Darius [illegible], is an affair of state in the monarchy of the Achaemenides, and yet there sufficed the duration of two or three reigns to introduce this exotic element into a religious system which seemed to exclude it; Artaxerxes Mnemon already made a place for Anahit in the official religion, and erected altars to her. Thus in historic times we have been witnesses of a phenomenon, that must have been frequently produced in the earlier period; that borrowing made by the Aryan world from the Semetic world is repeated many times and under many forms. The Greeks were like the Persians, the immediate neighbors of the Assyrians and Babylonians; by the intermediation od other peoples the fruits of the civilization of the great Semetic states came to them. Those distant relations followed a double route, the way of the sea and the way of the land.

Note 1.p.28. Histoire de l'Art. Vol. V. p. 412-417

Note 1.p.29. Especially see the Memoir, so rich in ideas and

facts, that Ernest Curtius published under this title:- Die griechische Götterlehre von geschichtlichen Standpunkte (Preussischer Jahrbücher. vol. 36. 1875). We have made numerous borrowings in the pages that follow.

By way of the sea, the Phoenicians served as intermediaries.[2] The feminine deity, who is found everywhere that the ships of the Phoenicians landed, appears in the Greek myths under two forms, sometimes as a wandering goddess, under the changing features of an Io, Europa, Helen or Dido, sometimes as a sedentary goddess. The Phoenician merchants established their goddess in Cyprus, the territory farthest east where was anciently settled a Greek people; all the ports there are known where they opened their agencies, all points where occurred contact between Syrians and Greeks. Under the name of Aphrodite, which is probably only an alteration of Ashtoret, the Syrian goddess passed among the Greeks of Cyprus;[3] the same influence carried the goddess and her worship very far toward the West to Cythera, quite against the coast of Europe, and on that coast itself at Corinth and even elsewhere. These are uncontested facts; the most jealous defenders of the autochtony of the Olympian gods do not dare to deny this origin; but they call Aphrodite the sole foreigner on Olympus. Is that assertion well founded? We do not believe it. If the routes followed on the continent by the oriental influences are less easy to recover, the discoveries of Botta and of Layard, Place and Sarzec, the study of Assyrian sculptures and of cuneiform inscriptions daily reveal relations between Greece and Assyria, that formerly were not suspected. We begin to conceive better the nature of the feminine deity, who in the Semitic religions is grouped in the first place with the great male god; this is the same being under different names, Belit (Beltis, Mylitta) at Babylon, Istar in Assyria, Nana in Elymaid, Annat in southern Chaldea. All these names, each of which designates a particular aspect of this divine essence, is likewise applied to a goddess, whose activity is not limited to a certain body isolated from nature, to certain of its manifestations, but is nothing else than the power itself of this nature, the moist principle of all growth, the matrix that receives all the germs, that bears without intermission and nourishes without ever being exhausted.

Note 2 p.22. For whatever are the elements that the oriental religions furnished to the Greek pantheon by the intermediary of the Phoenicians, one cannot refuse to take into great account the brilliant memoir of V. Berard. (De l'origin des cultes arcadiens. Essai de methode en mythologie grecque. 1894. Thorin). Doubtless there are in that work some confusion and too many h hypotheses, many that appear hazardous, especially since the author has not taken the trouble to separate them, and to devote to each of thec a systematic exposition; but he has no less demonstrated that Phoenician influence made itself felt in Greece, even in districts where up to the present time men have not even dreamed of seeking the trace. He recognized a Syrian Baal in the Zeus, that was honored on Mt. Lycaeus by human sacrifices, and this conjecture presents the highest degree of probability to which such researches could lead. Among the indications that evidence relations established between the Phoenicians and the ancestors of the Greeks of history, one should not forget to mention the numerous terms, that the Greek language has drawn from the common fund of Semetic idioms, and that especially designate either plants and animals, or products and common objects imported by commerce. Various lists have been drawn up; perhaps the most complete is that presented by W. Muss-Arnolt under this title:- On Semetic words in Greek and Latin. (Transactions of the American Philological Association. Vol. XIII. 1892. p. 35-156.

Note 3.p.22. Histoire de l'Art. Vol. III. p.282. Note 1.

This deity of Chaldean origin, one again finds in western Asia, on the soil occupied by peoples of different races, by those Heteans whose language and ethnic affinities have not been well difined, by the Semites of Cappadocia and of Cilicia, by the Aryans of Armenia and Phrygia, of Lydia and Caria. She is adored in Armenia under the name of the great goddess Artemis, under that of Ma in Cappadocia, and of Anaitis at Zela in Pontus. In regard to the last sanctuary, the Mesopotamian origin of this worship is attested by Strabo, as well as for Armenia.[1] Thus the principal centres of the worship of this great goddess of nature are distributed as so many stations on the principal caravan routes leading to the Euxine and the Ægean seas, and this is across the territory of peoples, who are the nearest relatives of the Greek tribes established on

the coast. Why was the transmission arrested at the limit of the territory of these tribes, why was the thread broken at the moment when it reached the coasts of the two seas? All along their shores we find a series of sanctuaries and feminine deities, that all present the same fundamental conception, a conception that on these coasts cut into such a great number of little autonomous states, suffered various changes of form in the active and subtle minds of the Greeks. If the primitive identity has been mistaken, this is because the Greeks have been too much isolated from their neighbors. The precious metals delivered to the Greeks in ingots and in weighed blanks according to the Babylonian standard received from their hands a stamp, that permitted them to pass as national coins; thus the religious ideas that dominated in western Asia, adopted by the Greeks, were struck again by the Greeks and marked as a new coinage. On these coasts of the archipelago, the pantheistic idea broke into so many rays, that until our days men are unable to recognize the unity of the primitive origin.

Note 1.p.30. Strabo. XVI. 1, 4; XI. 14-16.

These principles being fixed, one has no trouble to verify what traces have been retained from that origin by several deities, that Greece had made her own to the point of sometimes forgetting from whence they came. The nature goddess of Asia was venerated on Sipylus under the name of Rhea-Cybele, and when the Aeolians and Ionians addressed their homage to her, they did not forget that she was the sovereign of the mountains of Phrygia; but it was not the same for Artemis, whose name seems to be of Armenian or Phrygian origin. Artemis that a bond of close relationship already attaches to Apollo in Homer, is one of the divine figures, to which the Greek imagination in time succeeded in giving the most accomplished form; but this form, the result of prolonged elaboration, did not prevail everywhere, and it is the oriental goddess that one recognizes in the sanctuary of Ephesus, a point at which converge Phoenician influences exerted by sea and the Assyrian influence transmitted by land through an entire series of intermediaries; nothing is less in the Greek taste than the strange aspect of that image, whose body is covered from top to bottom by several rows of breasts.[1] The celebrated worship of Hera at Samos has the same basis as that of Ephesus. All these

deities of Asia Minor have the same character of vague omnipotence, the same indeterminate features. It is otherwise on the soil of Europe. There among the Greeks and Italiots is everywhere a marked tendency to idealize the gods. The idea of the supreme god, such as realized in the type of Zeus, remained predominant in Europe; it prevented that nature goddess from assuming in Hellas the same supremacy as in Cyprus or at Ephesus. What was also peculiar to Greece were the efforts made to establish a definite relation between this goddess and Zeus, whose spouse she became here and there the lover, elsewhere the daughter, rich material for the inventions of the poets. Here, wh where the goddess is conceived as wandering, she is the object of a secret amour of Zeus; this is the case of Io and of Europa; there is adored as a sedentary goddess, and is united to Zeus by an official bond; they celebrated at Argos the marriage of Zeus and Hera, at Dodona that of Zeus and of Dione. A very ancient tradition makes Dione a daughter of the ocean; attests that her worship was brought from beyond the sea, and came to be added to that of Zeus. One will also note the place occupied in several of these cults by the dove, the bird of the Syrian goddess, for example in those of Aphrodite and of Dione.

Note 1.p.31. On the Artemis of Ephesus and the transmission to the Greek colony of an entirely Asian cult, see the memoir of Ernest Curtius, Beiträge zur Geschichte und Topographie Kleinasiens. (Ephesos, Pergamon, Smyrna, Sardes). 1872.

It is in the marriage of Athena, so profoundly Greek in the aspect that poetry and art have lent to her, that may be perceived some half effaced traits by which one believes that he divines the influence of the exotic prototype, from which has been taken so many different impressions, and this feeling is still stronger when he studies the myths of Demeter and of Kora. Kora under the title of Despoina, "the Sovereign", takes in certain places the part of a supreme deity, and is confused with Cybele here, there with Aphrodite, with whom she has certain emblems in common. Demeter is a dispenser of life; her attributes were sometimes those of Aphrodite, sometimes those of Athena or Cybele. At the bottom of her mourning is concealed the idea analogous to that of Aphrodite weeping over Adonis. No goddesses have better retained their naturalistic character than Demeter and Kora, or have taken less of an ethnic and po-

political character.

However brief they may be, these indications suffice to cause recognition in several of the principal goddesses of Greece, of varied forms of the same divine type, that represents the power of nature operating in the damp soil nourished by the dew of heaven. Thus vanished the distinction that men pretended to establish between Aphrodite and the other inhabitants of Olympus. Aphrodite is not the only daughter of Asia, that has received from the hospitable genius of Greece letters of a grand naturalization. Thus falls and opens in wide breaches at each discovery made by history, that barrier which national pride had formerly raised between the Hellenes and those called barbarians by them, an imaginary barrier before which in modern times, were too long arrested incomplete science and enthusiasm into which entered some superstition; but the originality and the beauty of the Greek deities lose nothing from the change of the point of view. We only admire the more the creative activity of Greek genius, in seeing that it has known how to make of that formless idea, that had only found expression in the Orient by an indefinite accumulation of symbols. From this pantheism that lends itself badly to the conditions of sculpture, Greek art derived free and living persons, from that universal goddess the national gods. According as the Greek cities have wandered more or less from the primitive oriental tyle, they have attained a degree of civilization more or less elevated; thus we see the cult retain a character more materialistic at Corinth and at Partae in Achaia, where was perpetuated the institution of hierodule courtesans, than at Delphi and at Athens; Now Athens and Delphi took a very different part in the development of the Greek genius, than did Patrae of even the industrious and commercial Corinth.

Another conclusion:- it is necessary to renounce the search for the origin of each of the goddesses of Olympus in as many different primitive conceptions as there are distinct divinities. Mythology thus becomes a morphology. If this were the place to commence the study, what we should have to seek, is how a very general idea was conceived and modified by the different Greek tribes, by what stamp each has marked it. Nothing is more interesting than to follow the Greek mind in this work of transformation and appropriation, than to recover the methods

that it has spontaneously employed. This work was already very advanced when the arts of design began to lend their assistance; but they alone could carry it farther and complete it. It is by its form that is determined the living being; now that form described is only perceived an a whole; only the form impressed on the material comprises that precision, and permits to mark, by variations of form and color, and especially by inflections of outline, the difference of souls, to mark as distinctly so that such a face or such a body gives to the observer the feeling of the individual, of a being unique in the world, that is distinguished by certain particular traits from all beings, that it sufficiently resembles to take rank in the same kind a and the same species.

The most interesting part of the book that we propose to write will be the history of the efforts attempted by sculpture to continue this work, and to lead it to its end, efforts that from century to century were happier as the execution became more assured and more free. The poet first gave a certain consistency to these superior types, slowly sketched by an idea, that under the appearance of ingenuousness already had a singular power of analysis; he it was that traced as a first sketch figures in which are incarnated these theoretical conceptions; but the artist resumed the fixed outlines and modeled the features and members of these images, who made them so marvellously beautiful, that they imposed themselves forever on the imagination of men.

For fifteen centuries have been overthrown the altars of Zeus and Apollo, Aphrodite and Athena; yet still today, when art u undertakes to translate general ideas, it cannot escape the temptation or rather the necessity of having recourse to the forms that Grecian sculpture formerly created for the same purpose. And of all solutions of the problem, that found by the Greeks is still the most satisfactory, and when it was adopted, t the principles and method not changing, one reaches the same result. Our ideas are more complex than those of the ancients, and our feelings have shades that their simpler souls never knew. The modern artist will occupy himself in marking that difference, or if you wish, that superiority. To obtain this effect he will count less on the diversity of attributes, than on the power a and depth of expression; he will desire to place something in

the features of his figures, that is not in the antique marbles, somethng finer and more varied, more moved and touching; but e even when he shall succeed in that attempt, he will still be t the disciple and the continuer of the Greek masters. By their example and like them, from the subtle and impassioned study of the human form, will he demand the means of making visible to the eyes,what by itself does not seem possible to be represented by lines and by colors, the principal modes of existence, the ideas of taste, strength and quality.

Chapter II. Architecture.

1. Conditions given to architecture by the Dorian invasion.

If we form an accurate idea of the general character of the period, that follows the fall of the Achaian kingdoms, we must not expect to find there the trace of an original brilliant d development of architecture. Warlike and poor tribes have menaced, harassed, and then in most districts have driven into exile the last representatives of the ancient dynasties. The invaders took possession of the best lands; in spite of their ramparts and their grand monuments, they reduced to a secondary state the royad cities of Minyean princes of Iolcos and of Amy-clea. After the victory, the chiefs that had led to the combat the Dorian bands lived in their rural domains, as the kings of Sparta have always done, in the midst of the tenants by whom they caused them to be cultivated; they had not yet had time to acquire the habit of luxury and the taste for building. As for the vanquished, for those groups of emigrants who had fled along the coasts of Thrace, or across the islands of the Archi-pelago, then had to fight against the Mysians, Lydians and Ca-rians to end by settling in Asia Minor, they had too much to do in the first moments to think of undertaking structures of some importance; it was only after many years of tranquil possession, that among the representatives of the great Achaian families, there could arise in the hereditary princes of the new cities, the desire to profit by the security refound and reconquered wealth to construct for themselves palaces, which by their size and ornamentation recall those, in which the popular poetry c caused their heroic ancestors to dwell.

Between the 11 th and 8 th centuries, architecture was then scarcely able more than to continue by a sort of routine in the practices already consecrated by custom. It does not appear that during this space of time the condition of the surround-ings were very favorable to the soaring of that art; men did not have to erect edifices only such as the Cyclopean walls of Argolis, the palace of Tyrins, and the domed tombs of Mycenae. In the entire extent of the vast areas of the territory to wh-ich we refer our researches, we do not find the ruins or even the vestiges of a single building, that we dare to attribute w with entire certainty to one or another of the three or four centuries, that elapsed between the Dorian invasion and the

first olympiads. That gap in monumental tradition we can only attempt to fill by the aid of scattered information found in the writers, particularly in the Homeric poems.

2. Materials and Construction.

The entry of the Dorians into the Peloponessus must have changed nothing in the habits of the Greek mason. The newcomers caused their houses to be built by the workmen, that they found in the country, and the emigrants carried to the opposite shore of the Egean sea the methods that their fathers had transmitted to them. Rubble and crude bricks continued to form the body of most structures. Homer does not mention these materials; this is because, as in the walls of the habitations of Tiryns and of Mycenae, they were everywhere concealed either beneath panels of wood or coverings of metal, or were under roughcast and that concealed them from the eye. There is perhaps an allusion to this plastering in a passage of the Odyssey.[1] It is in relation to the polished stones on which the princes of the people, like Nestor at Pylos, sat before the gate of the royal dwelling. The poet says that those stones are "white,"and he adds two words (apostildontes aleiphatos), that the scholiasts interpret thus:- "brilliant as if they had been rubbed with a fat body;" but they introduce there an "as if", that is not in the text; one cannot suppose that Nestor sat on an oiled slab, which would have spotted his garments. Is it not more natural to translate "aleiphar" by "coating." The stones would have been coated with milk of lime. At Tiryns, it is not alone on the surfaces of the concrete that forms the wall, that one finds these coatings of lime; traces of them are also found on the great split blocks or those of sandstone cut with the saw, which play the part of antes before the ends of the walls.[1]

Note 1. p. 36. Odussey. III. 408-409. -- Helbig. L'epopee homeric expliquee por les monuments. (Translation Trawinski. Didot. 189 . p. 124-125.

Note 1.p.37. Dörpfeld in Schliemonn's Tirynthe. p. 247.

If in the greater number of structures, this stucco served to conceal the poverty of the masonry, there were however more careful constructions where the stone remained visible. It is this kind of construction that the poe has in view when he compares the close ranks of the Myrmidons to "close set stones", that the mason adjusts when he builds a lifty house, that must

resist the force of the winds;"[2] he represents to himself a wall, where the stones are very large in dimensions , leave no hold for the gusts of the tempest, thanks to the arrangement of the joints. Homer elsewhere applies another epithet no less expressive to the stones, that enter into the composition of these walls; he says that in "polished stones"were built the fifty chambers of the palace of Priam,and the dwelling of the magician Circe.[3] These walls of "close set" or "polished stones," t that the epic singers had under their eyes, one can represent to himself as quite similar to those enclosing the gate of lions at Mycenae. They were built with beds and regular courses; the surfaces were dressed with a tool.

Note 2.p.37 Iliad. XVI. 212-213; Odyssey. XXIII.,193..

Note 3.p.37. Iliad. VI. 244; Odyssey. X. 210, 253.

Nothing leads one to believe that men prided themselves in setting materials of very great dimensions, like those, whose enormous size astonishes one at Tiryns and at Mycenae. Megalithism assumes ambitions, that the men of that time do not seem to have experienced; it assumes the concurrence of very numerous men, that one could not manage. These conditions were realized at several points of the Greek world in the course of the primitive age. But during the succeeding period, the social conditions were less ready to favor that kind of effort. This is what the ancients themselves had felt. They never hesitated at the most remote date, that it is proper to assign to the walls of tombs, in which we have recognized a legacy of Achaian civilization; they always attributed them to that mythical age, whose great event was the war of Troy, and which closed with the Dorian conquest.

There is no mention in Homer of burned bricks or tiles; it was only to make vases that clay was subjected to the heat of the kiln. As for wood, it continued to play a part as important as in the past. The mountains of Greece must have been covered everywhere by dense forests.

This wood being in abundance, the workmen inserted it as anchors of crossed timbers in his rubble masonry and his masses of crude bricks or tempered earth; thus he constructed the rampart which the Greeks had built on the shore of the Hellespont before their vessels. The poems also contain several allusions to the fir timbers of which was made the carpentry of the roof,[1]

to the cypress planks that formed the jambs of the doors, and to the pieces of ash that served as sills.[2] The poet does not forget the planks, that in the same doors composed the swinging door.[3] He usually applies to the planks composing these panels the epithet "shining."[4] Yet they were not all ornamented by sheets of metal, like the doors of the palace of Alkinous, where gold shone, or the bronze doors of Tartarus.[5] It was most frequently the polish of the wood, perhaps rubbed with a varnish, which gave that gloss.

Note 1.p.38. Odyssey. XIX. 37.

Note 2.p.38. The same. XVII. 339.

Note 3.p.38. The same. II. 344; XXI. 137.

Note 4.p.38. Iliad. XIV. 169; Odyssey. VI, 19; X, 230, 256, 312 etc.

Note 5.p.38. Odyssey. VII, 83, 88, Iliad. VIII, 15.

It is also probable that the supports, that sustained the beams of the roof in the great halls of the Homeric palaces, were entirely of wood, as in the palaces of Tiryns and of Mycenae; that trunks of trees were the columns, that in the palace of Alkinous stood around the hearth, the columns where Arete leaned his seat, or one hung on a hook the lyre of Demodocos. Homer does not explain himself on that subject; but Pausanias saw at Olympia an old column of wood, split from top to bottom and supported by ropes. To shelter this shaft, that was said to have belonged to the house of Oenomaos, they had placed over it a roof borne on four columns of stone.[6]

Note 6.p.38. Pausanias. V. 20, 3.

3. Funerary Architecture.

Between the age when the exploits of the Achaian heroes furnished to epic poetry the primary material of its songs and that when this poetry died after having completed its work, there was produced a notable change in customs; the rite of cremation was introduced into Greece; it tended to replace that of burial in the obsequies. Not a hero died before the walls of Troy without the kindling of the funeral pyre for him. It would be an affront to the dead to not be extended on that last couch by the hand of a friend or of a relative. To hasten the combustion, he enclosed the corpse in the fat of slain victims; he placed near him vases filled with oil and wine, whose contents flowed over the pyre; he brought the torch of dry branches,

and when the flame had done its work, he collected in the still heated ashes the whitened bones, and deposited them in the funerary urn.[1]

Note 1.p.39. Iliad. XXIII. 160-178, 249-255; XXIV, 787-801; . Odyssey. XXIV. 65-84.

By what route was that practice of cremation disseminated in the Greek world? Did the Greeks receive it from one of the peoples in contact with them? Or did they come to it themselves, when they changed the ideas, that they formed of the condition of the dead? We have elsewhere tried to solve this problem; we shall limit ourselves here to a summary of the conclusions that we have reached.[2]

Note 2.p.39. G. Perrot. La religion de la mort et les rites funeraires en Grece. Inhumation et incineration. (Revue des Deux Mondes. 1895. Vol. 132. p. 98-127. Also see the beautiful work of Erwin Rohde. Psyche, Seelencult und Unsterblichkeitsglaube bei den Griechen. 1894. This is the work of both a learned philologist and of a keen analyst of ideas, and of a philosophic historian.

Cremation was not borrowed by Greece from foreigners. There is no trace of that rite in Egypt, Phoenicia, nor among the peoples of Asia Minor, such as the Carians, Lydians and Phrygians. From the spontaneous labor of the Grecian mind must we demand the reason of these changes. Men have thought to find this reason in the precarious existence that the Dorian invasion caused to the tribes, who saw themselves forced to leave their homes to seek others in the islands, in Thrace and Asia.[3] Those men that were lost in the course of these migrations, they could no longer deposit near their ancestors in a family tomb. To bury them in a district to be abandoned the next day was to condemn their remains to be forever deprived of that homage, which was the consolation of the dead; it was even to expose them in that tomb over which no person watched, to find themselves some day cast on the surface of the ground by the blade of the spade. The means of protecting the remains of cherished beings from all profanation, would be found in cremation. An urn in which was enclosed the calcined bones could always be carried with them from camp to camp, until the time, when having reached the termination of its travels, the tribe finally entrusted this deposit to a soil that belonged to itself.

By this feeling was Homer inspired, when he makes Nestor propose to burn on a single pyre the bodies of all warriors, that just fallen in the first battle, and to unite all their ashes beneath a single mound, "so that," says he, "when we return to our native land, we may carry to the children, each for our part, the bones of the fathers."[1]

Note 3.p.39. Helbig. L'epopee homerique. p.83.

Note 1.p.40. Iliad. VII. 335 336.

Unfortunately these two verses appear to be only an interpolation due to a rhapsody that had to explain why the Greeks undertook such a great labor; the reason that he gives for it is most awkward. All those bones are mingled in the pyre and the tomb; how then at the moment of departure could be recognized those of a certain dead man? Besides, nowhere is there a trace of that purpose in any other portion of the Homeric poems. Beneath those mounds erected on the shore of the Hellespont, after the victory and departure of the Greeks, continue to repose the ashes of the heros that fell before Troy.

Then one can explain the change in the rite only by the progress itself of Greek ideas. The primitive conception was that of a life very similar to that which we lead beneath the sun, of an incomplete life, always faltering, that continued in the tomb, so far as the piety of the living was applied to support it by sacrifice. That conception had determined the character of the Mycenaean tomb, like the Egyptian tomb, it made a reduced copy of the dwelling of the living. Yet the mind, all disposed as it was to content itself in such matters with vague ideas and confused images, ended by being anxious concerning the contradictions, that experierce did not fail to make to this naive hypothesis of survival in the tomb. Instead of this dead man that men had believed, that they fed and refreshed in his tomb, when this was opened at the end of some years, no more was found than bones injured by dampness. Before that nonentity it becam difficult to affirm the persistence of the being, and yet men could not resolve to admit that nothing more remained of what in the previous day had been seen full of life, strength and wisdom.

They they came to ask themselves, if it was not necessary to seek elsewhere what was no longer found in the tomb, what endured when the organs had been entirely dissolved. Something in-

indefinable which men could not decide to renounce, they figured him as a sort of reflection and phantasm of the body, that this projected into space before disappearing; it was compared to smoke, to the apparitions of a dream, to the shadow cast on the wall by him.[1] The term finally employed by preference to designate it was image (eidolon). If this image had no thickness, if when seen by the eyes the finger could not touch it, it no less retained the features of whom it represented. With the memory of the past it also kept the feelings, that caused to beat the heart of the men, whose fame it perpetuated. Almost immaterial, light and intangible, how did it allow itself to be shut within the prison of the tomb? Yet it was necessary for it to be somewhere, that it should have its dwelling. That house was a mysterious country of silence and darkness, Hades of Erebus.

Note 1.p.41. Iliad. XXIII. 100-101; Odyssey. X, 495; XI, 207-80

Where was Hades placed? None could say; it was very far, toward the North, on the shore of the ocean; but the shade, as soon as it was separated from the flesh, did it of itself find the way, that path by which so many other shades had already passed?[2] Those sister shades, those "images of those who had ceased to suffer", it went to rejoin them in the dreary extent of the uncultivated land, where flourished the pale asphodel. In time from this conception came that of the happiness reserved for the just in Hades and the punishment that strikes the wicked. This last conception corresponds to a new advance of thought; it already appeared in a verse of the Iliad and in fifty verses of the Odyssey.[1] Both of these texts belong to t the series of most recent retouchings suffered by the Homeric poems.

Note 2.p.41. The idea that to find this route, the shade needed a guide, appeared only in the last book of the Odyssey, that did not form a part of the rest of the poem, and was only added later. There alone for the first time Hermes appears as psychopomp or guide of the souls. (Odyssey. XI. 575-625).

The tale of the visit of Ulysses to Hades permits to be divined, how much the mind of man was still attached to the first conjecture suggested to him by the enigma of the dead. The phantoms evoked by the hero are mute, until they have wet their l lids with the blood of the slain victims; only then when they have drunk, they resume a gleam of life; they have strength to

speak. This trait is not in place here; what have those empty shades to do with drinking and eating, who no longer have any flesh? The labor of reflection has in vain led to a solution of the problem, that is less materialistic than the preceding one, the poet continues it without perceiving the contradiction of the elements, that logically pertain to principle, that the intelligence seems to have passed and abandoned.

The belief in Hades, the assemblage and sojourn of the shades, has then but imperfectly triumphed; it is not substituted for the more ancient faith; it is superposed thereon without ever descending as before in o the depths of the souls of the peoples. Yet it could not fail to have a certain effect on the funerary rites, and by that action we are inclined to explain the change produced in the customs, when Greece commenced to burn the corpses, that had previously been buried.

After death, there remains for Homer only that impalpable shade, that however is the physical and moral image of the deceased. What particular vapors enter into the composition of this phantom, none have known him to state; but in any case, it was neither made of bones, of tendons or muscular fibres, of nothing that had any consistency or weight. It then appeared that it could be born, to take its flight toward Hades, only when all organic matter was destroyed. The fragments of the body, while not completely dissolved, prevented the human person from transfiguring itself into the incorporeal image, and as if it were volatilized. To hasten the moment of that separation, was it not a sure means to deliver that body to the devouring heat of the fire? That is certainly what was thought by the inventors of cremation; one divines this in the response of the mother of Ulysses addressed to her son, when he complained that he could not hold her in his arms:--

"But even on this wise is it with mortals when they die. For the sinews no more bind together the flesh and the bones, but the great force of burning fire abolishes these, as soon as the life hath left the white bones, and the spirit like a dream flies forth and hovers near." [1]

Note 1.p.43. Odyssey. XI. 218-221.

There the poet gives one to understand that the flame of the pyre looses and frees the soul, the psyche, which is nothing else than what he elsewhere calls the image, the eidolon; but

in the Iliad he expressed still more clearly the thought of his contemporaries, when he causes Patroclus to speak, who appears to Achilles during the night, to hasten the celebration of his own funeral rites:--

"Bury me with all speed, that I pass the gates of Hades. Far off the spirits of men banish me, the phantoms of men outworn, nor suffer me to mingle with them beyond the river, but vainly I wander along the wide-gated dwelling of Hades. Now give me, I pray pitifully to thee, thy hand, for never more shall I come back from Hades, when you have given me my due of fire." [2]

Note 2.p.43. Iliad. XXIII. 71-74.

One cannot state more clearly the decisive and liberating effect of cremation; it is like a sacrament that confers on him that receives it the right of going to find, if not happiness, at least repose in the common asylum of the dead. There is something of the virtues, possessed by the absolution given by the priest to the dying, in the Catholic faith. [3]

Note 3.p.43. Like Patroclus, Elpenor could not enter into Hades, because when he presents himself to the eyes of Ulysses, he had not yet been burned. (Odyssey. XI, 50 78). So that Rohde noted the fact (Psyche, p. 25), that if it is sometimes stated that the soul, immediately after receiving the mortal stroke, went or descended to Hades, this is only an abridged mode of speaking, that does not claim full accuracy. The poet expresses himself otherwise, when he desires to mark clearly that the dead has penetrated into the depths of Hades. After having talked with Ulysses of that sort of frontier where the hero has assembled the shades, the soul of Tiresias returns into the interior of Hades, "when he had told all his oracles."(Odyssey. XI. 150.). Likewise Andromache, when she speaks of her father and her seven brothers, that Achilles has slain, but to whom he accorded the honors of the funeral pyre; she says to them, "all these on the selfsame day went within the house of Hades." (Iliad. VI. 422).

One will note the last words of Patroclus:- "Once that I have entered into Hades, thanks to the flame of the pyre, I shall never return again on earth." Perhaps there is reason to seek there the echo of anxiety, which contributed to suggest to the Greeks the idea of cremation. It is known how much was disseminated in the middle ages throughout all Europe the fear of vam-

vampires, as they were called of those dead that were supposed to leave their tombs at night, to surprise the living while asleep and to suck their blood. Those beliefs, that appear to have disappeared from the West, still exist among the Slavs of Austria and those of the Balkan peninsula, as well as among the G Greeks of the islands and of the mainland. Everywhere, to put an end to the incursions of the dead suspected of being a vampire, the body is exhumed and is burned to the last fragment; that being done, one can sleep in peace in the village that its attacks desolated.[1] If the Greeks of today are not safe from those foolish terrors, why might not their ancestors be sensible to them three thousand years ago? Many traces have been found in ancient authors, of superstitions analogous to those relating to vampires and their murderous activity;[2] if these superstitions continued to trouble souls in civilized Greece, it is because they had their roots in a very distant past. The generations that believed most strongly in the presence of the always living dead in the tomb, would no fail to tremble, when they felt so near them this formidable neighbor, all whose caprices it was impossible to foresee, when they had on him by the propitiatory sacrifice only a feeble and intermittent hold. The destruction of the body by fire, of its teeth that could bite, of its nails that could tear the flesh, sheltered them from th that peril. What would one have to fear from a phantom, from a phantom further sent into distant Hades, that closed its gates on those, to whom it had opened them?

Note 1.p.44. See Pashley. Travels in Crete. 1837. Vol. II. Chap. 26. The author relates curious tales of vampires, that he collected among the Sphakiotes and other mountaineers of Crete.

Note 2.p.44. Those are the sons of Medea, who were unjustly put to death by the Corinthians, and punished them for this crime by causing their children to perish. (Pausanias, II, 3, 6); it was one of the companions of Ulysses, who was stoned at Temesa, a village of Italy, and avenged himself for it by massacring persons of all ages (Pausanias, VI, 6,3); those are e especially female spectres, that are called according to the place, empouses, lamies or mormolykies. It is still believed, that they feed on human flesh; but by preference them attack bodies young and beautiful, because the blood is purest. (Phil-

(Philostrotes. Life of Apollonios). Ploto olso speoks of certoin impure souls, who hove not been oble to free themselves e entirely from the bonds of the flesh, remoin wondering ond stork phontoms oround the tombs. (Phedo. Sect. 69).

Whether such did or did not concur in accrediting the new conception and the new rite, wherever this prevailed, it must produce the decadence of funerary architecture and impoverishment of the tomb. If the tomb were not the eternal dwelling of the dead, it was no longer necessary to give it those spacious proportions, that we have admired in the domed tombs. If it were empty, the soul having flown away to Hades, why should one continue to accumulate treasures, like those found in the excavations of the Mycenaean acropolis? Ashes enclosed in a vase also require much less space than a corpse, and to place this vase under shelter from every insult, it was necessary for a hole to be dug in the earth.[1] If man did not have everywhere the desire that his memory should survive him, this hole would be t the entire tomb; but men desired that a visible mark should indicate to future generations the place where reposed the remains of the prince or of the war chief; without an inscription, there was the tumulus rising above the surface of the soil,that attracted the attention of the passer, and induced him to ask the name of the hero, for whom had been erected the monument.[2] This tumulus was called the sign (sema). This term finally in current usage came to designate the funeral mound, when it referred of obsequies. Men spoke of raising a sign, or rather of depositing it, because it was made of heaped earth and pebbles, placed on a base of great stones, and surrounded at the outside by great blocks, that must prevent the materials from sliding.[3]

Note 1.p.45. The bones of Potroclus were collected in o golden urn (Iliod, XXIII, 253), ond those of Hector in o golden c cosket (XXIV, 795); then they were deposited in o pit (XXIV, 797).

Note 2.p.45. This preoccupotion of moking on eternol memoriol wos divined in the words of Agomemnon oddressed to Achilles, in relotting to him how were celebroted his funerol rites under the wolls of Troy:-- "Around thy bones, we, the socred ormy of the Argives, skilful in hondling the lence, we piled up o greot ond beoutiful tomb on o projection of the shore of the brood

Hellespont, so that it was visible afar at sea for the men that are born and for those that will then come.(Odyssey, XXIV, 80-84)

Note 3.p.45. Nowhere is the method followed more clearly indicated than in these two verses of the 23 d book of the Iliad. (255-256).

The material of this substructure is specified in the 24 th book (797-799).

These tumuluses with their rounded slopes covered by turf, d differ little from each other except in size and by the dimensions of the stele placed on the summit of the mound. When he describes the obsequies of Patroclus or those of Hector, the poet does not mention these steles; but this is because he does not enter into all the details of the ceremony; It suffices for him to recall the principal circumstances. The placing of the stele seems to have been required; it can be inferred from a f formula twice repeated in the Iliad. When Zeus decides to allow his beloved son Sarpedon to succumb under the blows of Patroclus, he announces that Death and sweet Sleep will carry him away into Lycia, "where his brothers and friends will honor him by a tumulus and a stele; for that is the homage due to the dead."[1] The custom of marking by a stele the place where the dead has been interred dates back to the preceding age. The stele we found at Mycenae in the funerary enclosure of the acropolis and in the rock-cut tombs;[2] We have even recovered some indications leading one to suppose, that it also surmounted the dome of the great tombs built in the lower city.[3] The stele is then a rough stone or a stone cut with smooth faces; but sometimes one of these faces is decorated, either by ornamental motives or by figures, that recall the favorite occupations of the deceased.[4] Were there still found in the time of Homer on the steles, drawings and representations of that kind? Nothing gives reason to think so. When Elpenor expresses to Ulysses the desire, that a distinctive sign may mark his tomb in the eyes of men, what he desires is, that there should be raised on his tomb the oar, that he has so long held in his hand.[5]

Note 1.p.46. Iliad. XVI. 456, 674.

Note 2.p.46. Histoire de l'Art. Vol VI, p.347,588 763-775.

Note 3.p.46. The same. Vol VI. p. 601.

Note 4.p.46. The same. Vol. VI. Figs. 359,360,361,362,364.

Note 5.p.46. Odyssey.XI. 75-78; XII. 10-15.

The erection of the mound had then entered so much into the customs, that it was not omitted even when one could not have the dead on the pyre. In that case, men believed themselves relieved of a duty by constructing the tumulus; although that was empty, it would prolong the memory of the dead; the honors rendered to that fictitious tomb, even if not having the same efficacy as cremation and interment, while awaiting better, would be a satisfaction accorded to the wandering soul. Telemachus proposed to do that on the day when he obtained the certainty of the death of Ulysses; he erected a cenotaph to him.[1]

Note 1.p.47. Odyssey. I. 290-292; II. 220-223.

If the development of conceptions of the kind of those that we have analyzed could have been subjected to the rules of a rigorous logic, the worship of the dead would have ceased by full right, where the rite of cremation prevailed. Every offering is interested. The sacrifices offered on the tomb had the object of ensuring to the living the good offices of the dead; when they were shut up in Hades, one would have no further reason to make gifts to them; thus in Homer one finds no allusion to a worship that must be continued on each anniversary on the tumulus erected to the hero. Yet it is again the ancient belief, that inspires Achilles, when in the evening of the day that he killed Hector, he made the blood of the victims run around the body of Patroclus, when on the morning of the morrow the Myrmidons cut their hair and scattered it over the body, when Achilles places his own hair in the hands of his friend, when finally around the pyre, that he sprinkles with oil and honey, he sacrifices sheep and oxen, four horses, two dogs that had belonged to Patroclus, and twelve young Trojan prisoners.[3] Does not one feel there still in these libations and this slaughter, the persistent empire of the primitive idea, of the need that he felt to furnish the dead with a nourishment, that would prevent him from perishing by inanition, and for companions that should serve him in the tomb?

Note 2.p.47. Iliad. XXIII. 34.

Note 3.p.47. The same. XXIII. 135-153; 166-176.

Thus in princely funeral rites, many traits also recall the preceding regime, at the expense of one of those inconsistencies, that embarras little the feelings and the imagination. Yet the adoption of a new rite could not have failed to have

its effects. From the moment that one no longer believed that the dead inhabited the tomb, why did he deposit objects there, which would have no utility to it? Hence the custom of burning with the dead the clothing and arms of the deceased, instead of burying them in a vault. "Burn me with my arms", said Elpenor to Ulysses, "with all that I have."[4] Likewise when Achilles slew Eetion, father of Andromache, "he did not despoil him," says the poet; A religious respect forbade him;"but he burned him with his arms of beautiful work, and built a tumulus for him".[5]

Note 4.p.47. Odyssey. XI, 74 XII, 13.

Note 5.p.47. Iliad. VI, 417-419.

In the case where the rite of cremation had prevailed everywhere with the consequences that it comprised, the Greek cemeteries of the classical age would have nothing to teach us; the piety of the successive generations would not have accumulated those precious deposits, where archaeologists have found the best of their prizes. By good fortune, the rite of interment was maintained beside that of cremation, and even when man made use of the second, it was the first that always remained the master and controller of the tomb. Where it coexisted with its rival, even with those that had dropped it, it continued to i impose practices, that in theory found in it alone their justification. If it thus retained until the last days of antiquity its tacit and sovereign empire over the souls of the people, by a stronger reason its authority must be scarcely weakened at the ending of the epic period. Thus in regard to the condition of the dead, while professing the belief whose first outlines are found in Homer, Greece did not at all adopt the type of burial suggested by that belief. If this type be the only one mentioned by Homer, this is because during a certain time it was in favor in the cities of Aeolia and of Ionia in which epic poetry assumed its final form; but also it must have been but a temporary fashion, and a little later, they returned to the cavity cut in the rock and more or less richly furnished. The model that the authors of the Iliad and of the Odyssey had under their eyes and scarcely recognized merely in the mounds, that still rise at several points on the plain of Troy.

Schliemann made excavations in all those tumuli, as well as in the hill in the Chersonesus of Thrace, to which is attached

the name of Protesilas.[1] These excavations permit those monuments to be divided into two kinds. Some are merely imitations due to the caprice of a Hadrian or a Caracalla. We do not have to occupy ourselves with these imitations; interest only attaches to those tumuli, that seem to date in a time near that of Homer. Such appears to be the case for that one 250 paces from the shore of the Hellespont at the foot of cape Sigeia, which still rises about 40 ft. from the level of the plain. The position occupied by it allows it to be identified in all probability with the mound alluded to in the Homeric poems, and that all antiquity has pleased to regard as the tomb of Achilles. It is indeed a mound of moderate dimensions, that was the aim of the words placed by the poet in the mouth of Achilles:- "I do not advise you to make the tomb too high; but that it be suitable; finally, you will make it wider and higher, you Achaians, who shall survive me and remain in the ships with numerous banks of oars".[1] The diameter of this mound at base is only 98.4 ft. A well sunk from the summit to the rock found nothing, except toward the bottom were clods mixed with pieces of sandstone, above which layers of clay alternated with a blackish soil. Neither charcoal nor bones; if the mound received the ashes of the dead inclosed in a vase, this deposit was not found in the course of the workmen. Was this a true tomb or was it a cenotaph? That can only be known by entirely destroying it. This would be much trouble for small benefit, and perhaps one would regret having caused to disappear a monument, toward which in memory of the poet have been turned the eyes of so many obscure or illustrious travelers. (Fig. 1).

Note 1.p.48. Schliemann. Ilios. Chapter 12.

Note 1.p.49. Iliad. XXIII. 245-248.

However partially it has remained, the excavation sufficed to fix approximately the age of the tumulus. Schliemann divides into two groups the lessons that he collected there. The first comprises the very numerous fragments of badly burned vases with thick walls, of gray or blackish paste, in which he recognized a common pottery fabricated in the Troad from the most remote epoch until the origin of the Aeolian city. The second group is formed of the remains of a finer and better burned pottery with a red or black glaze decorated by bands of a dark tone, that rise from a light ground; what this pottery recalls

to him is that found by him in the Mycenaean acropolis outside the royal tombs.

Shafts sunk in several other tumuli have given nearly similar results. They were made in a mound situated near that of Achilles, and that Lechevalier named the tomb of Patroclus, in the Pacha, Besika and Karagatch mounds or tomb of Protesilas. Dimensions vary:- thus the Besika mound is 262.5 ft. in diameter and 47.6 ft. high; the Karagatch mound occupies a still larger area. In the last hill the pottery is ornamented by incised lines filled by a white powder with a more primitive character; but with these shades the resemblance is very marked. No chamber is made in the thickness of the mound; neither remains of structures, human remains nor even vestiges of the pyre. The tomb is everywhere reduced to be merely a heap of earth; this earth was piled over a cremated body of which no trace h has been found, or indeed it was placed as a seal on a memorial, that the piety of the survivors proposed to enclose within the tumulus, if one may so speak.

Nowhere but in the Troad and in Thrace have been found a tumulus like those described by the poet;[1] elsewhere that have been found tumuli that are rightly attributed to the period c closely followed by the Dorian invasion, the type of those tombs is not that which we have defined from the Iliad and Odyssey; with some secondary differences, it is much rather that of the Mycenean age, as stated in studying the Attic cemeteries, and especially the cemetery at Athens, which separates the inner from the outer Ceramicos. There have been opened many tombs containing pottery of a very particular character, that archaeologists are in the habit of terming pottery of the Dipylon, because in the interments near the gate so named (the double gate), examples of this pottery have been collected in greater number than elsewhere.[1] the oldest of these tombs are those of generations, that by the date when they lived, could not be very distant from those Ionians of Homer, in whose tales is mentioned only a single rite, that of cremation.

Note 1.p.50. Indeed in Asia Minor is a cemetery where the rite of cremation was alone employed, and that appears to belong to the period now occupying us; it is the Carian cemetery of Assarlik between Halicarnossus and Myndos. Described by Paton and Dümmler, it was well studied by Helbig, who has shown

what analogies the enterments there present with those in Homer. (Ueber die Nekropole von Assorlik in Karien; Nachrichten d. K. ges. d. Wiss. in Göttingen; Phil.-hist. Klasse. 1896. p. 233-252). The reason why we do not insist here on this cemetery is, that it does not seem to us proved as Helbig thenks, that these tombs are those of the first Greek colonists, that established themselves on the shores of Caria; we incline rather to see in this cemetery that of one of the lod Carian cities, which there preceded the Gree cities, and whose walls are found at several places in that country. (Histoire de l'Art. Vol. IV. ,.viii. C3).

Note 1.p.51. Of all statements arising from these excavations, the most developed is that treating of the excavations made in 1891 under the direction of M. M. Stais and Kawerau on the Sopountzaky estate. The results of those researches have been given by MM. A Brückner and E. Persius under the title of Ein Attischer Friedhof. (Athen. Mitt. 189 . p. 73-208; Pls. VI-IX). Especially to that Article shall we constantly have occasion to refer. Also more than one fact is to be found in the Memoir that M. Hirschfeld first defined the characters of the pottery of the Dipylon. (Ann. dell. Inst. 1872. Vasi Arcaici Ateniensi. p.121-182). Finally, a very precious point of comparison is furnished by the results of excavations made by M. Philios at Eleusis on the acropolis; he found there a little cemetery contemporaneous with the most ancient tombs of Ceramicos. (Greek text). On the cemetery of Salamine belonging to the transition between the Mycenaean and Homeric ages, see Kawadias, Catalogue des Musees d'Athenes; 1895. p. 25-26. Interment and cremation were practised there at the same time.

Now not without surprise does one verify, that if about this time the rite of cremation was not unknown in continental Greece, it was practised there but exceptionally. On the 19 tombs of the Dipylon uncovered in the campaign of 1891, there was only one in which was certainly buried a cremated dead person, and yet it is one of those that from the character of their equipment appear as latest;[2] in all others were found entire skeletons or bones not calcined by fire. The rite of cremation never prevailed entirely in the antique world.[3] The poor seem to have always preferred interment, that cost less; but they were not alone in interring their dead.

Note 2.p.51. Ein Attischer Friedhof. p. 104-106; 148-150.

Note 3.p.51. This is confirmed by the result reached by M. P Paolo Orsi, when he excavated the oldest cemetery in Syracuse, that comprises the tombs of the 7 th and 8 th centuries, and which is called Del Fusco. He found 122 interments to 5 cremations. (Notizie degli scavi. 1895. p. 110-111).

In the cemetery of the Dipylon until the 6 th, 5 th and 4 th centuries, the cremated dead are mixed with those interred; y yet all these tombs evidence a certain freedom.[4] For Greece itself and other countries, the texts of the authors attest the simultaneous use of the two rites.[1] While at Rome most of the dead were laid on the pyre, one of the greatest families of the city, the Cornelia gens, never gave its dead to the fire. Sylla was the first Cornelius that was burned. From fear of popular vengeance, his reltives departed from the established custom for him.

Note 4.p.51. Brückner and Pernice, in Athen. Mitt. 1893. p. 78-79.

Note 2.p.52. Solon, supporting before the Lacedemonian arbiters the claims of Athens, which disputed with Megara the ownership of the island of Salamis, drew an argument from the fact, that at Salamis as at Athens, the corpses in the tombs had their heads turned toward the west, while the Megarans turned them toward the east. An envoy from Megara contested that assertion; but the objections presented by him assumed the current usage of the rite of cremation, both in Attica and in Megaris. (Plutarch. Solon. X. 4-5). Herodotus (V. 8) mentions the mixture of the two rites among the Thracians.

Note 2.p. 2. The stone slabs were found in place at Eleusis. (Ephemeris. 1889. p. 187). For the arrangemen of the tombs of the Dipylon, see Ein Attischer Friedhof. p. 94. 105, 112, 133. There were noted in the earth over those pits of the Ceramicos traces of color, that were explained as being the traces of c clay laid on the planks that covered these pits. (p. 150). What proves that there was a chamber with its ceiling is the tripod found in the tomb near the abattoir. (Athen Mitt. 189 . p.415, pl. 14); such an elegant article would not have been exposed to contact with the moist earth, which would have soon corroded it.

Like the tombs that we found at Mycenae in the enclosure near the gate of lions, the tomb of the Dipylon is a pit dug in the

earth and sometimes lined with dry stones, that received either stone slabs or wooden floors. The projections made at mid-height of the longer sides must have supported this covering. Sometimes the skeleton was deposited in a clay vase; this was done for a child and even for adults.[2]

Note 2.p.52. The same. p. 99, 133. The wine jar that contained the remains of a child is 4.6 ft. long and 5.0 ft. in its greatest diameter. The dead man buried therein could only be crouching with bent knees. Likewise at Eleusis. (Ephemeris, 1889. p. 188).

The pits of the Athenian cemetery are less deep than are those of the necropolis in which were buried the predecessors of the Atrides: the bottom was only 6.6 ft. below the surface, and the average dimensions of those pits were only 6.6 ft. long by 4.9 ft. wide. This difference is thus explained. Excavation, built chamber surmounted by a dome or cavity arranged in the rock, t the Mycenaean tomb was that of a family; the tomb of the Dipylon rarely received but a single corpse. At Eleusis, two or two-three bodies were sometimes placed in the same pit.[4] No systematic orientation, neither at Athens nor Eleusis' the dead have their heads placed indifferently toward north or south, east or west. At Athens, the corpses were extended at full length; at Eleusis they sometimes lay on the left side with legs crossed.[1] Neither at Athens nor at Eleusis is there a trace of a wooden coffin; the bodies must have been wrapped in a simple shroud.

Note 4.p.52. Ephemeris. 1889. p. 190.

Note 1.p.53. The same. 1889. p. 174, 174.

The attic tomb is then more modest than that of Mycene; but like that it evidences the same ideas and the same beliefs. Sacrifices appear to have been offered to the dead before interment; there are found here the ashes and bones of animals, either in the earth filling the pit or in the places, where were placed the food prepared for the occupant of the tomb.[2]

Note 2.p.53. Ein Attischer Friedhof. p. 127, 128, 132, 141, 147. Philios also recognized at Eleusis the remains of sacrifices. (Ephemeris. 1889. p. 184).

Various liquids, water, milk or wine, must have been poured into ordinary vases of heavy form and without ornaments, whose bottoms are still blackened by smoke; before passing into the tomb, those vessels had already long served on the hearth of

the hearth.[3] On the contrary, the hydrias found in several tombs are very carefully made.[4] They have a very elegant curvature and are decorated by paintings. It is suggested that these hydrias contained the water for the bath, that the young man or girl occupying the tomb would have taken on the eve of marriage, if death had not come earlier. We shall have here the most ancient form of those bath vases, that in the classical age were customarily placed on the tombs of the unmarried persons, men or women, and that later were chiseled on the marble of the steles.[5] There is further nothing more than a mere symbol in the representation of the bath vase; but for this symbol to have been familiar to every mind, was it not necessary for a preceding time, when the act thus represented was really performed, when the bath was actually poured into the funerary bath vase and enclosed in the tomb?

Note 3.p.53. The same. p.117, 120; pl. viii,2.

Note 4.p.53. One of the 19 tombs had the hydria. (The same. p. 143).

Note 5.p.53. The same. p. 144-146

All these vessels were arranged as if the master of that dwelling actually had used them. Near the vessels containing the beverages were cups of various sizes, and in the neck of the hydria was placed a sort of ladle, that served to dip out the liquid filling the great receiver.[6] The little phials were filled with perfumed oils; when found, one of them still had its clay stopper.[1]

Note 6.p.53. The same. p. 145.

Note 1.p.54. Fin. Att. Fried. p. 115.

The dead were decorated by jewels like those he had worn in life, but less heavy.[2] If it were a man, he had at his side his iron sword suspended by a shoulder belt, and beneath his hands were his daggers and his spears.[3] If it was a woman, near her were placed boxes decorated by overlays of bone or ivory, in which she formerly kept her jewels and toilet articles.[4]

Note 2.p.54. The same. p. 101-128.

Note 3.p.54. The same. p. 107, 108, 133. Rayet, who was at Athens at the time of the excavations of the Ceramicos, also was a witness of the presence in the most ancient tombs of a "heavy sword with a wooden handle, of a slender knife and of two javelin heads; all those arms were of soft iron."

(Histoire de Ceramique. p. 23, 24). Likewise at Eleusis.(Ephemeris. 1889. p. 18 ,.

Note 4.p.54. Athen. Mitt. 1893. p. 120-125.

There were not taken from those graves the statuettes of terra cotta, rude images of a diety protecting the dead, that abound in the tombs of the Mycenaean age; but at least one of those pits has yielded li‑tle figures of ivory, that appear to have played the same part.[5]

Note 5.p.54. Ein Att. Fried. p. 128-131. Hist. de l'Art. Vol. VII. pl. 3.

Where the rite of cremation was employed, the equipment retained the same character as in the tombs of intercenss. The pit is similar, and there was deposited an entire assor‑ment of the same vases. There is only one difference. The calcined bones are enclosed in a bronze urn deposited at the very bottom of the pit.[6] Elsewhere that urn was supported by a tripod of very careful execution. (Fig. 2).[7]

Note 6.p.54. The same. p. 91-93, 104. 102.

Note 7.p.54. Athen. Mitt. 1893. p. 414, 415. The urn was not found in place on the tripod, which had been overturned.

Particularly by its external part,the tomb of the Dipylon is distinguished from the Mycenaean tomb. It likewise recommends itself by a visible sign of the affection of the survivors; b but here that sign was neither the tumulus, as under the walls of Troy, nor the decorated stele of Mycenae. If there have been found a Athens, Eleusis and in other cemeteries, some stones in the form of slabs, and there is reason to believe that these were formerly erected over the tombs; these were stones almost rough, that bear neither figures nor mouldings of any kind. (Fig. 3).[1]

Note 1.p.55. p. 154. Ephemeris. 1889. p. 175, 179, 184.

The art that suffered least from the impoverishment of the Greek world and the lessening of industrial activity was that of the potter; the needs to be satisfied were too variedfor it ever to have ceased, even in the most troublous times. That r relative superiority of the ceramist suggested the idea of requiring from it the monument, which formed the visible portion of the tomb. Terra cotta thus replaced the chiseled stone; a c clay vase most frequently served as a monument.

In the history of the Greek tomb, there is no other example

of such an arrangement; hence it was not respected at first. A Above the tombs were gathered fragments of large and much ornamented vases; but men imagined, that according to a custom previously mentioned, those vases were broken on the day of the f funeral rites and cast into the grave.[2] That was an error. Men learned this when one of the tombs recently excavated one of these vases, that filled the function of stele, was found in the same position assigned to it at the moment of completion of the obsequies, and by means of that discovery has been restored the primitive appearance of all that entirety. Fig. 4.[3]

Note 2.p.54. Rouet and Collignon, Histoire de la Ceramique grecque. p. 24. Philios had already noted that the fragments of very large vases, like those of the Dipylon, were found at a level sensibly higher than that of the vases of smaller dimensions placed at the bottom of the pits; but that peculiarity was not explained; he believed that those great vases had served as ossuaries. What compelled him to abandon that conjecture was the fact, that the fragments of those vases appeared at a slight distance below the actual surface of the ground. (Ephemeris. 1889. p. 174).

Note 3.p.54. In the added sketch has been restored only the floor, added by our artist, and the upper part of the vase, already restored by Brückner.

Above the urn or skeleton and supported by a floor was a certain thickness of earth; but the pit was not entirely filled. That remained half empty, and in that cavity at about 3.3 ft. above the bottom of the pit was placed the vase, that took the place of a monument, sometimes a great amphora with four handles and sometimes a cratera; it had the foot set in the filling, which gave it a bearing; for half or two thirds its height, it was protected by the walls of the pit; so that one of them remained intact up to the level of the banks of the pit; the upper part alone, that rose above ground, had been crushed. In spite of the fragility of the material, those clay monuments y yet offered certain guarantees of duration, while the cemetery was protected from profanation by the pious care of the families. Those vases were of very great dimensions; one of them has been restored at the museum of Athens with a height of 5.9 ft.; another from the same place is 5.25 ft.; that rising above

the tomb as represented by us was 3.6 ft. To vases of that height it was necessary to give very resistant walls: all these vases are more than 3/8 ins. thick; thus they were not at the mercy of a slight accidental shock; to break them required blows of a stone or a hammer.

However, even if in these conditions the vase had not the solidity of the stele, it offered the advantage of furnishing the artist a means of expression more in harmony with his inexperience. The scenes that he desired to represent to define the monument, he had less difficulty in tracing on the clay with the brush, than to model them in the calcareous tufa. The drawing was indeed singularly awkward, but it was impossible a not to seize the meaning of the pictures decorating the bodies of those vases, paintings with themes supplied even by the funeral ceremonies. These ceremonies were divided into several acts by the painter, each of which was represented separately. There was first the exposure of the body at the house, the prothesis, with what Homer calls the groaning; the dead was extended on his bed with face uncovered; the relatives, friends and the women of the family, beating their breasts and tearing their hair, addressed to it those passionate apostrophes, whose tradition is preserved in Greece in the "mirologhi" of the Maniotes, that greatly resembles the "vocero" or appeal of t the Corsicans (Fig. 5); but what positively attracted the multitude was the transfer to the cemetery, the "ecphora". The couch with its funeral burden was placed on a car drawn by horses led by men walking before them. On the wooden platform drawn along the streets the mourners, some kneeling and the others standing, were grouped around the body, uttering continued screams (Fig. 6). The funeral car was a sort of moving theatre, like that on which Thespis later displayed budding tragedy in the towns of Attica.

There were perhaps also games; men ask if in the series of cars represented on those vases must not be seen a preparation for the races, that occurred after the interment of the corpse. (ig. 7). The prize of the race would have been one of those tripods sometimes represented on the necks of the amphoras, a and an example of which was found in one of the tombs of the Dipylon (Figs. 2 and 8). These equestrian games, with the tripods contested there would still be a trait connecting the age

of the Dipylon with the Homeric age, when were rendered to the princes honors, the custom of which was lost among the historical Greeks. The apparatus of the obsequies at Athens continued to be simplified. That difference between the ancients and the new customs was taken into account by the Athenians, it is recalled by the author of the dialogue called Minos, that has come to us under the name of Plato:-- "Thou knowest", says one of the speakers, "that thou hast heard related what were once among us the rites observed concerning the dead; before the procession we slew victims; then we caused the marching of women carrying vases for the libations and the bath. Nothing of all that occurs now".[1] When Solon enacted a law regulating the order of the funeral rites, that limited the cost and forbade too noisy an expression of sorrow, he only had to cidify the custom, only to record the changes begun to be introduced in customs.[2] Minds were cultivated and refined; men inquired if there was not something slightly barbaric in that profusion of wealth cast into the tomb, in those piercing cries uttered in public, in those immoderate and almost immodest gestures, whose violence caused women to forget even modesty; it was felt that greater discretion and restraint better suited the sadness of the last farewell.

Note 1.p.58. Minos. p. 1. On the meaning of the word here employed by the author to designate women, literally scattering, see Etymologycum magnum.

Note 2.p.58. Plutarch. Solon XXI. Demosthenes against Macarcatos. 62.

Before those scruples originated, a real spectacle was the burial of deceased of high rank, as divined from the enormous vases that we have described. Those must be very dear, and could only be executed for the first personages of the city, for the chiefs of the "naucraries"; in the naval scenes figured in the lower series of the decoration is recognized an allusion to the title borne during life and to the maneuvres directed by the men of noble race, in memory of whom had been erected these m monuments.[2] The entire city gathered to the funeral processions of the Eupatrides as to a festival.

Note 3.p.58. Fin Att. Fried. p. 152, 153. The exercises over which presided the naucraries are represented here, as on the Attic steles of the 6 th century; a horse is led by a groom

near the base of the cippus, indicating that the deceased belonged to the class of knights.

The vases that furnish us with this precious information had another purpose, that reveals a curious peculiarity:- they have no bottom or the bottom is pierced.[1] Is it supposed that this bottom was omitted only to save labor? That is not probable w with the mastery of the workmen tha fashioned articles of that height. If they did this, it was for motives of a different k kind. The arrangement of the tomb of the Dipylon implies the worship of the dead, a worship having one of its most important rites as that of the nourishing libation. One recalls those p pits with walled sides, in which we found at Tiryns and at Mycenae cavities into which was formerly poured the blood of victims, wine and milk;[2] at bottom only an earthen utensil through which to reach their aim, passed the liquids intended for the nourishment of the occupant of the sepulchre.[3] The first vases placed over those mortuary cavities must have been to replace those basins of masonry. Instead of distributing at random the libation on the ground, it was thus caused to run into a receiver placed over the corpse, and which could pass through the orifice by which the living communicated with their dead. The commonest jar sufficed to fulfil that office; but once that t the vase was there, placed in the cemetery, it was enlarged and was decorated to ma e of it at the same time the sign of the tomb, the evidence attesting the supreme homage rendered to the dead by the family and the city.

Note 1.p.60. This fact had already struck Hirschfeld, Koumanoudis and Philios, who proposed no explanation. (Annali. 1872. p. 164. Practica. 1873-4. p. 18. Aphemeris. 1889. p. 175 177). This was given by Bruckner and Pernice, p. 155.

Note 2.p.60. We forgot to state in the preceding volume (VI), that these hollow altars or sumpsbore the name of "eschara" among the Greeks. Scholiast of Euripides ad Phoenissas; V, 274. (Greek text. See Hesychius). Porphyros says that the eschara served for sacrifices offered to the Chtonian gods and to heroes. (De antro nymphorum. Chap. 6, p. 7).

Note 3.p.60. Histoire de l'Art. Vol. VI. p. 283, 284, Figs. 81, 82; p. 323, Figs 102, 103; p. 343, Fig. 114 A; p. 571 etc.

If one had on the subject of the cemeteries of the rest of Greece such precise data, as those given by us on the graves

that contain the vases of the Dipylon, it would perhaps be possible to indicate other tombs contemporary with those at Athens and of Eleusis; but it is very probable, that for that epoch the cemeteries of continental Greece and of the islands were not distinguished from those forming the subject of this study except by traits of a very secondary importance. Thus in Boetia has not been found a trace of vases of exceptional dimensions, that were placed on tombs. That custom seems to have remained peculiar to Athens. At Thebes and in the other cities of the same region was continued the use of the slab placed on the grave. Thus on a vase, certainly from a Boetian workshop, is seen below the representation of the funeral ceremonies the tomb indicated by a cippus, whose form recalls that of the Mycenaean steles, and more yet that of the steles of Bologna. At the right and left of that stele are the two horses of the dead, facing each other. (Fig. 9).

In Boetia, Cyprus and elsewhere, have beer opened many graves, a certain number can date back to the period occupying us, and yet no more than in Attica, the tomb has neither the visible form nor the internal arrangement of that described by Homer. In spite of the appearance of the new dogma and of the new mode of burial, the Greek tomb then retained during even the period when its ideas changed, the character impressed upon it by t the primitive beliefs and the practice of interment.

Yet if the tomb at the Ceramicos of Athens does not have the same size as at Orchomenos or at Mycene, if it no longer comprises neither richly decorated facades nor majestic domes, and not even deep grottos excavated in the depth of the tufa, one can indicate two reasons for this difference. The first is that the social condition in Greece after the fall of the Achaian dynasties, is no longer what it had been while those reigned in their impregnable castles. So far as one can discover the condition of the Hellenci world during the two or three centuries that followed the Dorian invasion, that was a time of troubles and c wars, since when the conquest was completed, and that occurred the subsidence of a moderate and rustic life. Those opulent princes, intent on building, lavish patrons of artists and of goldsmiths, such as were the Achaian kings, Greece never saw again under another name, excepting much later under the tyrants of the 7 th and 6 th centuries, the Perianders,

Clistenes, Polycrates and Pisastratides. Until that moment parcelled into little groups, that after recent shocks sought their equilibrium, it had neither powerful chiefs, illustrious by distant adventures and enriched by war, oligarchies paiently ambitious, nor bold and ardent democracies. The former royalties with the prestige of their secular antiquity, are dead to never recover, and the city as an association of equals only prepare its framework. Elsewhere, among the Ionians as among the Dorians, wealth and authority are in the hands of the nobles, that were called at Athens the Eupatrids or "sons of good fathers". Those are the tombs of these nobles that have been found in the Ceramicos, with the monumental vase surmounting them, the pottery and caskets, the arms and jewels deposited there. It was no longer necessary to distinguish them from those of the common people; but those aristocratic interments must all be nearly similar; in giving to one of them unusual dimensions, one would have risked the injury of public feeling. Affairs must occur in the rest of Greece as at Athens. If it was proper in the privileged class to ornament and equip the tomb of the chief of the family, it would have appeared evil to place beyond equality in death, one of those that during life had only his part of the charges and honors at the disposal of the city. Whatever the desire that the affection of the survivors had to indicate itself by the luxury employed in the arrangement of the tomb, it was constrained to consider that situation; a certain equality and a certain uniformity were imposed.

There is also to be calculated the effect of the change produced in ideas on the subject of the life after death. In spite of the resistance of the rite of cremation, the beliefs from which it sprang could not fail to ente into minds everywhere. It is true that these did not abolish earlier conceptions, that were profoundly imoresse, if one may so speak, in even the marrow of thought; They were added to them. The relative or friend that had been lost, one represented successively or even entirely domociled in the tomb, and mingled in Hades with the innumerable multitude of the dead. Whether one of these hypotheses was the negation of the other, men cared little. When the imagination enters this domain of mystery and of dreaming, where no conjecture can submit to the test of experience, is not embarr-

embarrassed by contradictions. Yet from the day when, at least at moments, one represents the dead as wandering on the banks of the rivers of Erebus, or later as tasting in that sojourn the joys reserved for the blessed, the attitude of the mind before this problem, that never ceased to torment it, was no longer what it had been previously. Doubtless men did not act as if the tomb contained only mute and insensible dust; they continued to equip it with the same articles and to pay the tribute of some offerings; but they no longer continued to see as clearly the deceased pursuing in the shades, by the virtue of the libation, the existence that he had previously led beneath the sun. Therefore some uncertainty, a sort of hesitation unconfessed, but which no less must have its influence on funerary architecture. No longer feeling the dead near himself, one was tempted to no longer devote himself to such painful efforts to make the tomb spacious and rich; especially men became unaccustumed to throw with full hands into it the precious metals, for which it was easy to find a better use. The excavations formerly found in our course no longer present the imposing dimensions and the sumptous decoration, that we have admired in sepulchral domes; the jewels that we shall see found will seem to us very light in comparison to those, that we have weighed at Mycenae.

4. Religious Architecture.

Vainly have we sought the temple on the sites of the fortresses of Tiryns and Mycenae, among the remains of the buildings in those limited areas, and what we do not learn from an inspection of the ruins, we have no resource to demand from written documents; there exist none dating back in that epoch. On the other hand the monuments represented have supplied us with some information. We have found there altars, before which are persons making a gesture of adoration.[1] Some inlays in metal alone, collected at Mycenae, appear to present the image of an edifice consecrated to worship;[2] but those little plates are of the number of works to which one is most tempted to attribute an oriental origin, and on the other hand if admitting them to be of native make, they only represent a building of very small dimensions, a large hut formed of an assemblage of beams. According to these data we have believed ourselves able to conjecture, that perhaps then were chapels in which were preserv-

certain objects to which was attached a particular veneration, either a sacred stone or the more or less rude image of some god, but that the ceremonies of worship were celebrated in the open air in consecrated enclosures, analogous to the high places of the Semites. For that purpose they gathered around the altar; the sacrifices were made on the bomos, a massive projection of stone or of turf.

Note 1.p.65. Histoire de l'Art. Vol. VI. Fig. 328[23], 429.

Note 2.p.6 . The some. Fig. 337.

It does not appear that matters changed much in that respect during the succeeding period, although by the creation of those divine types already seen in Homer, so clearly defined, the religious idea is singularly developed. The temple bears the name of neos or naos; but it is still of but slight importance. In the entire Odyssey it is not mentioned once. On the contrary, in the Iliad allusions to the temple of Athena occur several times; but the poet that describes the palace of Priam, its very careful construction and its numerous chambers, gives no indication permitting one to form an idea of the dimensions and of the appearance of the temple. All that he specifies is, that the edifice is situated on the summit of the acropolis,[2] and n that it is usually kept closed; when Hecuba comes to deposit n her gifts there, the priestess opens it with a key in her charge. This sanctuary contains a statue, doubtless a xoanon of wood;[4] The Trojan women placed on its knees the peplos, that they had embroidered in its honor.[5] Apollo likewise had a temple in the citadel; there he brings and places in the care of Artemis and of Leto his favorite Eneas, whom he has just brought from the field of battle and torn from the hands of Diomede; the temple is termed a great sanctuary.[1] Of the temple of Apollo Sminthius, whose priest is Chryses, all that the poet finds to say is, that it is graceful.[2] It is in vain for Zeus to be the greatest of the gods, nowhere is found an express mention of a temple consecrated to him. Zeus is moved by the fate of Hector, who does to fall beneath the blows of Achilles, remembers that the hero "has caused to be burned in his honor the thighs of many oxen, sometimes on the heights of Ida with numerous ravines, and sometimes on high within the city";[3] but the relation established by the poet between the holocausts offered on the summits of the mountain and those made on the most elevated point

of Pergamus rather forms the idea of simple altars, erected at the time the sacrifice was prepared; it is difficult for one to admit, that there was a temple on each of the heights of Ida.

Note 3.p.65. Iliad. VI. 86-87.

Note 4.p.65. The some. VI. 89, 298.

Note 5.p.65. The some. VI. 92, 303-305.

Note 1.p.66. The some. V. 446-448.

Note 2.p.66. The some. I. 39.

Note 3.p.66. The some. XXII. 169-172.

The so-called Homeric hymns are less ancient than the Iliad and the Odyssey; still at least some of them must date back to a time very near that when the two great epic periods began to extend throughout all Greece. Such is particularly the case for the hymn to the Delian Apollo, the masterpiece of that poetry. It was composed by a Homer of Chios, and all know the enthusiasm with which the poet boasts of the grand bea ing and beauty of his compatriots. He says that whoever sees them, gathered at Delos in their festal attire would be tempted to take them "for the immortals, forever exempt from the misfortunes of old age."[1] Now toward the 8 th century the Ionians, at last firmly established on the coasts of Asia Minor and in the largest islands near them, began to seek ou lets outside, launched themselves boldly on the sea, to enrich themselves by commerce and by the founding of distant colonies. The feeling of pride that bursts forth in the epilogue of the hymn is indeed that, which must be felt about that time by an ardent and youthful people, which admired itself for the intelligence and strength displayed, and for the rapid rise taken by its fortunes.

Note 1.p.66. Hymne o Apollon Delien. 151-152.

Thus we should freely believe that this hymn is nearly contemporaneous with the first olympiads. In the inquiry that we pursue, it therefor leads us a little farther than the epic period did. Now what further results from a passage of the hymn is, t that then the temple still occupies only a secondary place in the entirety of the arrangements that man had thought to create in view of worshi fixed limits, whose amplitude and happy arrangement added to the effect of the religious ceremonies. Nothing is more significant in this respect, than the expressions employed by the poet to recall how the homage and prayers ascend to Apollo. He says:- "Thou hast many temples and sacred

forests rich in trees; thou likewise cherishest all the heights from which the view extends afar and the highest tops of the lofty mountains, as well as the rivers that flow toward the sea; but still it is Delos that most rejoices thy heart."[1]

Note 1.p.67. Hymne o Apollo Delien. 113-145.

The impression left by these verses is, that Apollo then indeed had many temples, yet none that was sufficiently large to attract particular attention. The Delian temple is that most frequented and most famous of all those sanctuaries; now the poet that delights in describing the festivals celebrated at Delos, does not even indicate by a passing glance or by a picturesque adjective the architectural character of the edifice; he only qualifies it by an ordinary epithet, rich. The word t temple, neos, is not even found in the promise by which Latona reassures Delos concerning the intentions of her son, and promises that this island shall always remain the preferred abode of her son; it is no longer merely a question of the altar and of the sacred enclosure.[2]

Note 2.p.67. Greek text. Hymne. 87-88.

Then in each holy place where the faithful assemble, what s strikes the eyes is less the temple itself, the little house of the god, a modest shelter enclosing a very imperfect image or symbol of the nature of a rough stone, than the area whose soil resounds beneath the steps of the dancers, the altar on which is kindled the fire of the holocausts, or the sacred forest with the spreading branches of its evergreen laurels, or the strong boughs of its old oaks. The temple is too small to open to the multitude or even to the procession od singers and bearers of gifts. Sacrifices are offered in the open air, "near the well built altar",[3] and around it the choir performed its rhythmic evolutions. Then they go to repose in the cool shade of the adjacent forest. Thus the forest is a necessary adjunct of the temple.[4] It finally disappears, at least in many places, just as the enclosure or peribolos contracts, when the temple takes the place of the royal palace on the apex of the acropolis, on the narrow plateau termina ing it. How was a forest planted and made to live on the rock of the citadel of Tiryns or that of Athens?

Note 3.p.67. Greex text. Iliad. I, 448.

Note 4.p.67. The formula (Greek) reappears constantly in the

two hymns to Apollo. (Verses 143, 221, 245).

The hymn to the Apollo of Delphi seems less ancient than that in honor of the Delian Apollo; it gives the idea of an already rudimentary architecture. When the Iliad was composed, Delphi under the name of Pytho, was already a very important religious centre. Homer boasted of the treasures "enclosed behind the stone threshold of Phoebus Apollo, the archer, in rocky Pythos."[1]

The "stone sill", a part for the whole, representing the temple for him. This threshold of stone is also mentioned in the hymn;[2] but that enters into more details. The poet relates that an innumerable multitude of men lent the aid of their arms to the architects Trophonios and Agomades, sons of Ergínos and dear to the immortal gods, to build the temple of polished stones, to be celebrated forever by the hymn.[3] Apollo himself placed the "wide and very long foundations on which was seated the e edifice"; from one end to the other.[4] One divines what importance the constructor therefore attached to that part of his work. Before deciding for Pytho, Apollo had chosen for his temple another site near Haliarte, and there likewise he had commenced by laying on the earth foundations, that the poet characterized by the same epithets.[5]

Note 1.p.88. Iliad. IX. 404-405.

Note 2.p.88. Hymne, 295.

Note 3.p.88. The some. 296-299.

Note 4.p.88. The some (Greek). 294-295.

Note 5.p.88 The some. 255.

At Delphi had been retained the memory of a temple of Apollo, that had the form of a wooden hut.[6] Evidently to that sort of hut do not apply the verses that we have quoted. In the edifice that the poet had in view, stone plays a great part; it forms the foundations, the threshold, and doubtless also the wall of the building, for there must have been best found a place for the polished stones mentioned; but nothing implies that the columns were also of stone. Those supports must have been of wood, like the columns of the palace of Mycene. For a stronger reason, wood also furnished the material for the upper parts of the edifice, the ceilings and the carpentry of the roof. The building was entirely burned in 548 by a "fire that occurred of itself",[1] an accident that presumes a structure into which wood entered for a considerable part.

Note 6.p.68. Pousonios. X. 5. 9.

Note 1.p.69. Herodotus. II. 180; see I, 50.

Some other monuments of the same construction had the opportunity to escape destruction for long centuries, and they were shown in the time of Pausanias as venerable relics of the past. Such near Mantinea was the timple of Poseidon Hippios, that tradition also referred to Agomades and Trophonios. It was entirely built of timbers superposed and framed together. No doors; a suspended cord closed the entrance. Hadrian, the imperial ar archaeologist, to better preserve this curious evidence of the ancient ages, erected all around it a structure enclosing it like a shell.[2] At Elis was shown as a legacy from the same antiquity, a roof supported by pillaes of oak. No walls, it being a simple shed. It was stated to be a tomb, that of Oxylos; but it must rather have been a primitive temple.[3] At Metaponte was an old temple of Hera, each of whose columns was made of the trunk of an enormous vine.[4] At Olympia, in the temple of Hera already recognized by the ancients as the oldest religious edifice enclosed within the Altis, one of the two columns placed between the antes of the opisthodome was still a wooden column in the time of Pausanias.[5] This shaft was the last survivor of an entire series of similar columns.

Note 2.p.69. Pousonios. VIII. 10 2.

Note 3.p.69. The some. VI. 24,7.

Note 4.p.69. Pliny. H. N. XIV. 2.

Note 5.p.69. Pousonios. V. 16,1.

We shall not go so far as to derive from these remarks a conclusion, that would perhaps appear rasher than it really is; we infer only that from the 10 th or 9 th century there existed at the foot of Mt. Cronion a first temple of Hera, whose supports may have been again employed in the edifice described by Pausanias, but we insist on showing, that when about the end of the 8 th or perhaps in the 7 th century, there was constituted this Doric style, one of whose most ancient monuments is doubtless the Heraeon of Olympia, its religious architecture was at nearly the same point as during the course of the Mycenaean period. From one age to the other, the customs and practices of the constructor had changed little.

We have already mentioned the rock sanctuary of Cynthe of Delos, and that built against the mountain quite near the pea

of Ocha in Eubea;[1] so far no pottery has been collected, whose style would allow the reference of those edifices to one date rather than another. Greece has retained several of those old temples, deprived of all architectural decoration, that preceded the invention of the orders. They were retained as evidences of the simplicity of former times. They were not even built of great blocks like that of Ocha; there were some still more humble. Such at Panopea in Phocis was a chapel, whose walls were of crude bricks. What must render still more sensible the rudeness of the masonry was the statue of Pentelican marble, placed there long after the founding of the sanctuary.[2] Such likewise was an old temple of Apollo at Megara, also of bricks. Hadrian caused it to be rebuilt in marble. The edifice contained statues of ebony wood of the old type, two of which especially resembled Egyptian statues, and a work of Egina.[3]

Note 1.p.70. Histoire de l'Art. Vol. VI.p.654-658. It has recently been attempted to be shown that the edifice of Ocha had never been a temple, that it was the guard house of watchmen posted on the summit, that commands one of the passes most used from the Egean sea. Th. Wiegard. Der angebliche Temple auf der Ocha. (Athen. Mitt. 1896.p.11-17; pls. 2, 3).

Note 2.p.70. Pausanias. X. 4,3.

Note 3.p.70. The same. I. 42-5.

Perhaps one owes to the most recent excavations of Troy the discovery of an authentic example of the primitive temple. Those excavations have especially the result of separating the edifices of what M. Doerpfeld calls the sixth city, from the fortress with a perimeter much larger than that of the second or burned city, and protected by higher and better constructed walls. That fortress was contemporaneous with the ramparts, palaces and tombs of Mycenae and of Tiryns; this is affirmed by the vases, whose fragments are found mixed with the ruins of the buildings of that city, the real Troy of Homer, whose power and fall served as a theme of the epic singers. There near the exterior of the enclosure were brought to light the remains of several great halls, whose plans recall that of the principal room of the palace of Mycenae, the megaron.[1] In one of those buildings M. Doerpfeld is inclined to recognize a temple. That is preceded by a prodromos or vestibule only 3.3 ft. deep, and is a spacious room 50.2 ft. long by 27.2 ft. wide.(Fig. 10).

There was discovered still in place only the base of a column found at Troy from the first of the sixth layer. It is a flat slab of irregular form, on the upper face of which and cut in the same block projects a cylinder 1.87 ft. diameter and 0.92 ft. high. (Fig. 11). A wooden shaft was set on this cylinder. The part of the stone covered by the wood has remained smooth. On the contrary near the border, where the cutting was exposed to the air, the texture of the limestone is rough and as if worn. If from the entire diameter of the section of the cylinder be taken twice the width of that ring, one obtains the approximate diamete of the post; it was not less than 1.25 ft. Such a slender post could not alone support the weight of the ceiling; there is reason to assume three columns placed on the same axis in the direction of the length of the room.

Note A.p.70. Doerpfeld. Troja. Bericht etc. with 2 plans and 88 illustrations. 1894.

Note 1. p. 71. This is the building described by Doerpfeld under the title of "Geboude VI c(p. 22-25).

Doubtless in uncovering the edifice, nothing was found to reveal its purpose; like the other similar buildings, this might be the room of one of the chie persons of the city. Yet here are the reasons permitting one to suspect here the existence of a temple. This building is very near the place where was built under the sucessors of Alexander the Great the temple of Athena Ilios' the court extending before it was almost in the middle of the area of the castle, i.e., in the vicinity of the highest point of the hill, where according to the statements of the Iliad itself were built the sanctuaries and altars of the gods. That court enclosed by well built walls of masonry has the appearance of a temenos, of a sacred precinct. Of all buildings of the same kind, this is the only one having a vestibule with such slight depth. Everywhere else the vestibule is sufficiently wide for nearly as many to assemble as in the megaron, here on the con rary, this part of the edifice seems to have only a purely ornamental purpose, a peculiarity that accords with the hypothesis mentioned. What is important in the temple is the closed room supposed to be the habitation of the god. Now this chamber offers a trait found in no other of the buildings at Troy; here alone the hall is divided in two aisles by a row of columns. On the other hand, this very rare arrangement is exactly

that which characterizes one of the most ancient Grecian temples known to us, that of Neandria, an Aeolian city quite near Troy, where in recent times have been made singular discoveries.[1] One is tempted to think, that this is not a mere coincidence; to ask if he is not here in presence of a type of religious edifice, that dates from the primitive period, and which in that country would be perpetuated till in the full historic age.

Note 1.p.72. Koldewey. Neandria., Berlin . 1891.

Why one might have the idea of opposing this conjecture is the fact, that the building in which it is proposed to seek a temple does not present the orientation, that we believe should be attributed to all antique temples; its facade is turned toward the northwest; but it is known that even later this rule was sometimes neglected. Here further is what proves that it did not have a general application until quite late; also to the northwest faces the temple of Neandria.

In the entire external face of the rampart of the sixth city, the condition of the stone indicates, that it remained long exposed to the air. When the crest of the work was overthrown, the inhabitants did not trace a new line of defense before or behind the old rampart; they contented themselves by filling the breaches by superposing another wall, thinner and less careful in execution.[2] The people established on that hill seem to have been reduced then, and to have led for several centuries an obscure and mediocre life. It sheltered itself behind the earlier enclosure until the time about the end of the 4 th century, when was built of entirely different masonry that, whose construction has been attributed to Lysimachus. It was the same for the worship. The building described by us perhaps remained in that form during many centuries, the principal temple of the local deity. It would have been frequented at the same time as that temple of Neandria to which we have compared it. In the latter the art is much more advanced; but still between the edifices one believes to be found in the resemblance of the plans an original relationship, that gives this conjecture great probability.

Note 2.p.72. Dorpfeld. Bericht. p. 44.

We have been compelled to go back to Troy, even to a Troy contemporaneous with the Mycenae of the Pelopides, to find a

monument that appears to have some right to represent an entire vanished species, that of the temples concerning which Pausanias makes no mention of an order, rustic edifices, very different in arrangement and appearance, that had nothing in common but their religious purpose. Nowhere, neither in Asian Greece, in the islands, nor in European Greece, have been found ruins in which with certainty can be sought the temple, or at least the substructure of the temple contemporaneous with the epic period. Thus one has sometimes thought to recognize the work of Agamedes and of Trophonios in the strong walls, still intact and completely uncovered since the latest excavations, which at Delphi support at the south the terrace on which was placed the celebrated edifice containing the oracle of Apollo. We hold that conjecture as improbable. If the temple properly so called had only a slight importance from the time of Homer, is it probable that to support the sanctuary alluded to in the Iliad and the Hymn to Apollo Pythios, was constructed a platform with one side 292 ft. long? Besides the polygonal masonry, where in that wall it presents a close adherence to polymorphic blocks, does not have a primitive character; it rather belongs to the 6 th century than to the 10 th or 9 th. The wall in question must date from the reconstruction by the Alcmeonides.

The religious architecture does not seem to have made sensible progress in the course of that period. It remains for us to seek what civil architecture became after the Dorian invasion, whether it continued to enclose by powerful ramparts the sides of the acropolises, and to erect on their summits those great and richly decorated edifices, in which we have recognized the hereditary dwellings of the Achaian princes.

5. Civil Architecture.

The ancients never attributed to the heros of the Iliad and of the Odyssey the construction of the enclosures of Tiryns and of Mycenae, of those walls that are astonishing by the size of their materials, they gave the honor of them to the legendary workmen, the Cyclops, whom they placed almost outside the bounds of humanity. In that approximate chronology, that served them for grouping their myths, they had placed this intervention of the Cyclops at about the very beginnings of the Argive civilization, at the time of that Proetos who preceded Perseus and

Hercules. This meant that they had not possessed any exact memory of the age, when those great works were executed, that were regarded as much earlier than those dynasties of the Pelopides, who by the part that they played in the epic period, already b belonged in a certain measure to history. The epic poets then longer knew on that subject only what the tradition gave, that a little later was accepted by the tragic poets of Athens and by Pausanias.

Men asked why it occurred in Homer, who so frequently contrasts the vigor of the men of antiquity with the weakness of the men of his own time, that there is not the least allusion to the weight of those enormous blocks, that seem to have been raised in sport by the primitive constructors. This silence is explained by the real native land of the two poems. This is th that from European Greece, Crete and Egina, the Peloponnessus and Thessaly, the epic poets at the migration of the Ionians and Aeolians brought as a first sketch their tales of war and adventure; but it was in Asia Minor and in the adjacent islands where this poetry completed its evolution. Now at Smyrna, at C Chios and Samos, one was very far from Argolis; one was not even very near the ruins of Troy, that had been besieged by the valiant Achaians. If in Greece beyond the sea the names o the heros had not been forgotten, sons of Minos and Eachos, of Peleus and of Atreus, if there had been retained for each of them the traits first lent to them by the imagination of the singers, if even by the persistence of vases that retained the memory of the descriptive epithets that he placed in his work, he appeared to have retained a quite exact memory of powerful and wealthy cities like Orchomenos and Mycenae, if not ignorant that Troy owed its prolonged resistance to the solidity of its walls, those poets however did not live in the vicinity of fortresses, that had been erected to ensure to their masters the control of the rich countries of Beotia, of Argolis and of the Troad. They had not had occasion to experience before those walls the expression of surprise, whose trace would be found somewhere in their works, had they entered the galleries in the walls of Tiryns, and if they had passed through the gate of lions at Mycenae. The epic poets that supplied to Homer the materials of the Iliad do not even seem to have seen the wall of Troy c contemporaneous with Mycenae, that wall just uncovered by M.

Dörpfeld (Fig. 12).[1] Had they measured its height with the eye, it seems that they would have spoken in a manner less vague; they would have emphasized more the strength of that barrier, the obstacle that it opposed to the undertakings of t the Greek heros, that like Patroclus and Achilles came to strike it wit their spears i vain. Did not two immortals, Poseidon and Phoebus, in one year of labor build it for Laomedes, father of Priam? [2] It would have been natural, that to justify that tradition, the poet would be pleased to describe that rampart as he has described the shield of Achilles, the work of another god. Homer has done nothing, and the wall of Troy, that wall around which occurred the entire drama of a ten years' war, is fon him any wall, that he does not clearly represent to himself. If he thus remains vague, it is because the cities inhabited by him are not enclosed by walls; because he has never found himself opposite a rampart either built of cleft rocks, like that of Tiryns, or like that of Mycenae, of stones already well cut.

Note 1.p.75. Bericht. p. 38-56.

Note 2.p.75. Iliad. VII. 452-453; XXI. 443-447.

On the contrary, details abound where is concerned the fortified line constructed before their tents. The poet sees these country works similar to presented to his eyes more than once. The camp is surrounded by a ditch whose inner bank is equipped with palisades. Behind these rise the rampart. As foundations, trunks of trees and great slabs of rough stone; what Homer calls "steles".[1] Those slabs support the earth that forms the body of the rampart, and above it was held in place by ties of timbers. When Sarpedon tears out a part of those ties, the e earth slides; a breach opens in the wall.[2] At places near the gates are towers that seem entirely made of timbers.[3] This mode of construction, with the part played by wood, is nearly that found at Troy in the burned city, and also in Argolis; but here in the improvised work, bricks dried in the sun are replaced by tamped earth.

Note 1.p.76. Iliad. XII. 29, 259.

Note 2.p.76. The same. XII. 397-399.

Note 3.p.76. The same. XII. 36.

Here is what proves that the epic poets knew no other type wall from their own experience; in that ideal isle of Scheria

inhabited by the Pheacians, who are represented as men superior to the rest of humanity, if the poet of the Odyssey places a wall, this wall is only a barrier of wood. When Ulysses enters the city where Alkinoos reigns, he admires "the steps of the l long and high walls, where the palisades are well joined, marvellous to see".[4]

Note 4.p.78. Odyssey. VII. 44-48. One can merely see a poetic hyperbole in the mention of a wall of bronze surrounding t the entire island of Eolus. (Odyssey. X. 3). The poet seems to have represented to himself a wall of smooth stone, covered by plates of bronze, something like the walls of the chamber of the Treasury of Atreus. It is not possible for the walls of an enclosure to have been so covered. But to strike the minds of his hearers, the poe imagines the application to an entire wall of an arrangement, that in practice could be employed only for interiors or for richly decorated facades of monuments.

By what one divines of the history of the tribes to which we owe the epic period, is explained how was lost by them the habit of employing stone quarried in great blocks for the construction of indestructible ramparts. When the Aeolians and Ionians landed on the shores of Asia Minor, what was necessary to ensure them during a brief stay was an entrenchment, that protected them against the attacks of the natives. This result was obtained by digging a ditch; throwing inside the earth removed to form the rampart; by setting on the top of the bank a row of piles close together, they sheltered themselves. When the people at first hostile had been driven to a distance, or they were attached to them by the ties of commerce, they did not feel any need of strengthening their defenses. From Mysians, Phrygians and Carians was nothing more to be feared, and on the other hand, it does not seem that there were between the Greek cities of Asia Minor bitter and persistent enmities, like those of European Greece, causing wars between Argos and Phliante, Thebes and Orchomenos, or Thebes and Platea. Cast on the frontier and as if on the border of the barbaric world, those cities had too many common interests to be tempted to fight and to ruin each other. They were generally sufficiently distant from each other, tha each one had a suburb sufficing it; high mountains or wide gulfs separate the dominions of Smyrna and Phocea, of Ephesus and Miletus. Besides it was not on the side next the

main land that each of those groups sought to extend itself; its true outlets were on the side next the sea. Seeing themselves menaced neithe by their neighbors in the inteeior nor by their sisters of the same race, those cities appear to have only commenced very late to surround themselves by stone walls; they did not consider the day when they would have to d defend themselves against the Lydians, they against the Persians. Miletus was fortified when the Lydians attacked it; but Herodotus does not state the sort of rampart, that compelled Alyattes and Croesus to content themselves with devastating the fields and orchards of the Miletans.[1] The historians are more explicit for Phocea. When the Phoceans, after the fall of Sardis, had reason to fear the Persians, "they constructed around their city with great stones well joined," a wall that had several furlongs in length.[2] Phocea previously had only a wall of crude bricks, if it even possessed any enclosure. The author of the Odyssey seems to have represented to himself Ithaca, Pylos and Sparta as open cities; when he introduces Telemachus or Ulysses into them, there is no allusion to the gates that the visitor had to pass.

Note 1.p.77. Herodotus. I. 17.

Note 2.p.77. The same. I. 163.

Still there is more than one mention of fortified cities in the epic period. The city represented by Hephaestos on the shield of Achilles is enclosed by a wall, on the top of which ar women, children and old men.[3] More than one city receives the epithet of walled, or rather the poet recalls that it is furnished with towers. The cities to which this character is thus attributed are, besides Troy and Scheria, Gortyne, Tiryns, Thebes of Boetia and Thebes of Cilicia, Lyrnessos, Calydon, the city of Curetes, Pleuron, Pheia in Elis.[1] The sole one of these cities in which may be preserved a wall certainly preceding Homer is Tiryns, and one cannot doubt that the epithet refers to the Cyclopean masonry still existing today; but one cannot conclude that all the other cities so qualified had a wall as strong as that of Tiryns or built in the same fashion. Yet several of the cities to which attention is directed thus dated back in the primitive period; that is the case for Thebes and Gortyne. The Thebes of Cadmus and the Gortyne as a rival of Cnossos might have had Cyclopean walls that disappeared later.

For all as for Tiryns these are recalled by the epithet mentioned. Homer found it joined to the names of these cities in the old songs that he utilized; but he attached no precise sense to it; for the poet a rampart of earth and of wood, like that erected by the Greeks before thei camp, is the supreme effort of the art; did he not attribute to Poseidon the fear that such an important work should cause to be forgotten the wall that Apollo and he wit their divine hands erected entirely around Troy? To reassure his son, Zeus engages him to throw against that barrier, as soon as the Greeks have departed, the waves commanded by him. Those would soon efface all trace of the work of man, and where arose that obtrusive monument, should henceforth be seen only a sandy strand.[2]

Note 3.p.77. Homer. Iliad. XVIII. 514. See Iliad. XV, 737, and IV, 308.

Note 1.p.78. Helbig. L'epopee homerique. p. 119-120.

Note 2.p.78. Iliad. VII. 446-463.

Then it seems, that for what concerns the art of fortification, the architect in the time of Homer was less skilful and bold than during the Mycenaean period; he dared or knew not how to derive the same benefit from stone. From the idea that several reasons are given for the rude and warlike tribes, that established themselves in the most fertile parts of the Peloponessus, one is inclined to believe, that this domain of the new masters of Argolis and of Laconia also, was more rustic than that of the Achaian princes. At Sparta, that city which was a type of the Dorian state, the kings never seem to have had a palace; when they were not at war, they lived in their farmhouses on their lands as great rural proprietors. One feels afar the wealth of the palaces of Mycenae and of Tiryns, with the old Dorian law attributed to Lycurgus, according to which the doors of houses should only be dressed with the saw, and the roofs only with the axe.[1]

Note 1.p.79. Plutarch. Lycurgus. 13.

If for a long time, customs must remain very simple in European Greece, it was otherwise in the groups that the result of the invasion had driven into Asia Minor. Those emigrants had carried with them entrusted to the memory of poets the ancient traditions of their race, the memories of an age of adventure, power and glory; they had also brought with them the taste for

a certain luxury, certain habits of elegant and noble life. In the groups of exiles were artisans, trained in the practice of certain trades. The new cities were soon enriched by the cultore of fertile lands and especially by commerce, and saw again the flourishing of the arts cultivated by Mycenaean Greece. Th Their chiefs, descendants of the old families beyond the sea, did not fail to apply themselves to enhance the dignity of t their rank by the splendor of the surroundings in which they sought to place themselves. For them labored in the city the most skilful workmen, and for them also the Phoenician merchants drew from the holds of their ships fabrics with fine embroideries, arms skilfully inlaid with gold and silver, the most beautiful jewels, and vases of metal most sumptuously ornamented; all that served to decorate the person or house of the prince. This was frequented by the epic poets, by those singers, that like Demodocos and Phemios of the Odyssey, celebrated in the festal hall the exploits of the ancestors. To receive the guests gathered there, it was necessary for the r royal dwelling to have a very spacious room in which should find place on great occasions for all the nobles of the city. That dwelling must then retain certain traits that had characterized it in the preceding period. Hence we shall have no difficulty in showing as derived from the epic period all that it contained of that kind, by positive statements and indications more or less clear.

From the Iliad is not much to be derived. It is a tale of war. The Greeks are in the country. They live under shelters made of branches and reeds. As for Troy, it is seen in a a way only f from the outside; the poet especially shows the Trojans on the field of battle or grouped on the enclosing wall; there is scarcely occasion to follow them into the interior of the city. Yet it indicates in a rapid sketch the character "of the palace of Paris built for himself with the aid of the best carpenters then in Troy; this had bedrooms, a reception hall and a court, near Priam and Hector on the summit of the city".[1] One will note our translation of verse 316; (Greek text.

Note 1.p.80. Iliad. VI. 313-317.

If we have rendered by paraphases the two terms "thalamos" and "doma", this is for better understanding the same. Homer briefly recalls the three great divisions of the palace of My-

Mycenae, that are also those of the palace of his time. "Doma" is here synonomous with "megaron", that large room in which visitors assembled is the most important part of the house, that most attracts the eyes; hence the poet designates it as the house itself, the house in particular. The "thalamos" is the private portion of the dwelling; in a princely residence this quarter could contain but one chamber; for that reason we have employed the plural here. Finally the court or "aule" is a necessary dependance of the house; it is what we have seen in the plan of Tiryns.

Although described at greater length than that of Paris, the palace of Priam is done with less precision.[2] The poet speaks of the court or "aule", as well as of the "porticos with plain surfaces", that enclosed it; but on what he particularly insists is the extent of the private apartments, the very exceptional number of members of the family that had their reserved places. "There were in the house fifty chambers of polished s stone, built near each other; there the sons of Priam slept with their wives." Priam, that Asian patriarch, had almost as many children as Ramses Meimaoun; his entire family did not stay in those fifty chambers. There was another series of entirely similar rooms, that were intended for his daughters and their husbands; but these last rooms were on the opposite side, i.e., before the megaron in the outer court. They are placed in sixes on two sides of the court.

Note 2.p.80. Iliad. VI. 242-250.

Not a word of the megaron itself; we know nothing of the mass of the structure, that connected the outer court with its lodgings to the reserved quarter, the rear portion of the palace. There is an omission or rather an understanding, that is suited by only one explanation. None of the important scenes of t the poem has the royal residence for its location; Homer thus had no interest in making known the entirety of the arrangements by which the edifice was defined; but he conducts Hector there, who comes to charge his mother to assuage the anger of Pallas, and to seize that occasion for indicating by some chosen traits the grandeur and magnificence of that dwelling. What appeared to him most suitable to strike the minds of his hearers is the enumeration of those chambers in unusual number' also the care with which was executed the work of construction

and that of the dressing of the s one. No more was necessary; it is for the imagination to represent to itself the rest in keeping therewith, with the same appearance of size and wealth.

Quite different is the case of the Odyssey. In the dwelling of Ulysses is exhibited the prologue of the drama, and the ending occurs after varied accidents, that lead the poet to parade his personages in that entire house, from the court that precedes it to the most retired rooms, from the ground story to the upper story. He nowhere interrupts himself to describe the palace; but the circumstances themselves od this story lead him to make allusions to the principal arrangements of this building, sufficiently numerous that it has been thought possible to restore at least the plan. These attempts have led to very diverse results; but however marked the diversities, there is nothing that must discourage curiosity. Recent excavations have placed the archaeologist before more than one edifice offering singular relations to that Homer had in view; thus they have permitted a better definition of the terms of the epic language. This furnishes us with the means of presenting a plan on which it is easy to follow in all their proceedings, the actors in the final scenes of the poem. (Plate I).[1] A perspective view of the edifice makes these arrangements still clearer.(Plate II).[1]

Note 1.p.81. The best plan of the palace of Ulysses ever given appears to us to be that given by Jebb in his interesting study entitled; The Homeric house in relation to the remains ot Tiryns (Journal of Hellenic studies. 1888. p. 170-188). Yet the sketch that we present differs in several respects from that traced by our predecessor. In Note 9 on page 170 will be found in Jebb the list of the principal works, that have been devoted to the house of Ulysses. Helbig occupies himself only with the decoration and furniture of the house; he does not seek to restore its plan. All the texts relating to the Homeric house are methodically grouped in the Memoir of Dr. Joseph, architect:- Die Paläste des Homerischen Epos, mit Rucksicht auf die Ausgrabungen Heinrich Schliemanns. 2 nd edition. pp. 1 107. 2 pls. We have not always reached the same conclusions as that author; but he appears to have often seen correctly. One will also read with profit the observations of Puchstein on the Homeric house. (Archaeol. Anzeig.1891. p. 42, 43, in Vol. VI of

Jahrbuch); he states that the poet does not seem to have had in view always the same type of house, and that he has attempted to distinguish and define those different types.

Note 1.p.82. The kind of perspective chosen permits showing in their exact proportions the various parts of the habitation; but the use of this mode imposed by circumstances risks causing the buildings to appear larger than the reality; we must guard against that illusion. This residence occupies only a limited area of ground; in its greatest dimension the court is only 105 ft. between the porticos. The view indicates the different kinds of masonry employed in these structures, masonry in horizontal courses with projections, polygonal masonry of small cut stones, masonry of small rubble, walls of crude bricks and wood, facings of polished stone and of wood, etc.; Those buildings could not have all been built at the same time. At their upper part the walls do not stop horizontally at the same height; they have been leveled at different heights, according to whether it was desired to show the interiors of the halls or the su surfaces of the courts and terraces. The upper part of the enclosing walls is even sectioned by removal.

With its double propyleons and its high facade preceded by a double court, the palace of Tiryns must have offered to the v visitor an imposing appearance, that did not lack a certain elegance. At Ithaca, what is striking at first sight in the house of the prince, when viewed from outside, is less its appeanance of wealth and luxury, than its solidity and power of resistance. This results from the verses in which Ulysses, when he approaches his own dwelling in his role of a mendicant stranger, expresses the impression made on the mind of the spectator.

Eumeus, there is certainly the beautiful house of Ulysses!
It is recognized afar among all others.
Buildings succeed buildings; its court is surrounded
By a wall with its cornice, and there are solid doors
With double leaves; no man could force his way in.[2]

Note 2.p.82. Odyssey. XVII. 264-268.

This door with solid leaves we have placed in an angle, as Tiryns, but we start from the idea, which will be confirmed by the entire study, that the Homeric palace was smaller and simpler in arrangement than the Mycenaean palace; we then have not believed it necessary to restore here those propyleons with co-

columns found at Mycenae and Tiryns. The doorway (Plate I,A) however retains the arrangement already mentioned at Troy, and that characterizes the propyleons; it does not open directly to the exterior in the plane of the external face of the wall; it is placed at the back of a vestibule and precedes another, an arrangement that has something monumental and that facilitates oversight. A bench is placed against one of the walls of the outer vestibule.

In Homer, the word court is never used in the plural;[1] it is the outer court, the principal court is the only one in which the poet has occasion to conduct and exhibit his hero. At Ithaca is mentioned only a single court, on which opens the megaron; it must be entirely surrounded by a hood or portico, under which men sheltered themselves from sun or rain (MM). At the entrance of that court Ulysses saw lying on a heap of filth his old dog Argos, who died from shock, when he recognized his master after the lapse of twenty years. There was a dunghill in a corner of the court, and it was the same before the palace of Priam.[2] In the vicinity of the megaron, a part of the area had received special preparation; the earth was tamped, or even perhaps small pebbles were driven into concrete, as at Tiryns, and formed a sort of pavement there. The suitors played at quoits before the megaron on that artificial ground.(K).[2]

Note 1.p.83. Odyssey. XVII. 290-300. Iliad. XXIV. 164, 639-640.

Note 2.p.83. Odyssey. IV. 627.

From that court in the dwelling of Ulysses as in that of Priam, light was taken by certain rooms in which lodged the guards, servants and guests (F). At Troy the sons-in-law of the king thus dwelt in front and outside the house proper; there Telemachus himself had his chamber on the court. It would have appeared inconvenient for an unmarried may to live and sleep in the quarter reserved for the women, among the servants of the queen. The poet indicates that the chamber of Telemachus was "high and well in view."[3] That decided us to place a story on the buildings on two sides of the court. The stairs E lead to that chamber, which is shown in the perspective. Under it and on each side could be found rooms, such as for wood, winepress and oil mill. We do not assume high chambers on the side of that court into which opens the doorway; there must be found

the stables and stalls (B), as well as a sort of park in which were placed the animals brought for consumption by the family (C). As for the "beautiful enclosures", where Eumenes placed the swine that he brought for the visitors, while awaiting the time of slaughter, we place them beside the house (h);[1] there in that enclosure is ground with a little grass and some trees: it communicates with the court by a passage placed at the back on the left. A larger enclosure (m) extends behind the house; if one finds that it merits better the Homeric epithet, it suffices to assume an open door in the wall, that forms the back of the lateral enclosure.

Note 3.p.83. Odyssey. I, 425-426.

Note 4.p.81. The some. XX. 164.

There was also somewhere in the external dependances of the palace a structure mentioned only in the story of the punishment, that Telemachus inflicted on the servant women, that yielded themselves to the suitors. Ulysses ordered Telemachus to slay them "between the tholos and the strong wall of the court".[2] One may inquire if the tholos were not outside the court, if it is not necessary to seek between the tholos and the outer face of the wall the place designated for the execution; but would it not be improbable that one of the structures forming part of that entirety should thus be isolated in the country? Further, the sequence of the story seems to imply that the place marked for the massacre was quite near the entrance of the megaron. Telemachus and Eumenes caused those unfortunates to wash the floor, tables and seats of the great hall in which the suitors had been killed; then "having made the servant women to leave the megaron, he gathered them into the narrow space between the tholos and the strong wall of the court, from which it was impossible to escape".[3] It is not stated that the murderers drove those women out of the court; as soon as driven from the apartment in which they performed their last work, they were collected in the place itself, where they were to die. According to Telemachus, it would do them too much honor to strike them with the sword; he preferred to hang them, and to prepare the gallows, he takes a rope of a ship "and coils one end around the tholos, while he attaches the other to a great column".[4]

Note 2.p.84. Odyssey. XII. 441-442.

Note 3.p.84. Odyssey. XII. 458-460.

Note 4.p.84. The same. XII. 465-466.

What was the tholos and where must its place be sought? In the language of classical architecture the tholos designates an edifice of circular form, like that which Polycletos had constructed at Epidauros. What shows well that the poet has well in view a building of that kind is the expression, that he employed in describing the operation executed by Telemachus. He attaches the rope to the column; but coils it around the t tholos. The tholos is then a circular building, and that structure could have but a small diameter; otherwise it would be n necessary for Telemachus to have a rope of unusual length. That building must be elevated on a substructure to which one ascended by several steps (H); if the foot of the rotunda had rested on the ground itself of the court, and Telemachus had stretched the rope at the height of his raised arms, the bodies of those suspended would have touched the earth. To proceed to the coiling by means of a ladder would have been long and difficult. On the contrary, add a base that supports the rotunda; the hero stands on the level of the top of that solid, and with a turn of the hand ties the rope at the desired height. To fasten the other end on the shaft of the column would suffice a stool or even a stone found there. We assume a distance of about 16.4 ft. between the column and the tholos. If longer, the rope would not have had sufficient stiffness, and the twelve condemned could take that space.

What was the tholos? Various hypotheses have been profosed. Some have thought of a privy.[1] The conjecture is ingenious; it accords well with the intentions of Ulysses, who desired the servant women to perish"by a shameful death"; but it is permissible to ask if the Homeric habitation actually contained a room for that purpose. It would still be possible to see there a circular structure like that frequently found in our country places, erected as a protection from dust over the orifice of a well or cistern. Or indeed might it not be a rotunda open to the air below the shelter of a mushroom roof, a sort of kiosk, where one came to sit to enjoy the coolness of the evening? I have frequently seen kiosks so placed before the konaks of Turkish beys; they pass long hours there in drinking coffee and taking their kief.[2] We have placed this tholos in a little side

court communicating with the great court; (Plate I, G); from the elevated base on which rests the rotunda it would have been easy to see the country over the wall. In the angle of that court is found a sor of shed; on the side next the court is seen a column, that must support the edge of the roof. If the purpose of the edifice always remains conjectural, the arrangement that we present is plausible; it corresponds to the episode in which is mentioned the tholos.

Note 1.p.85. Joseph. Die Palaste. p. 28.

Note 2.p.85. G. Perrot. Souvenirs d'un voyage en Asie Mineure. p. 141-143.

Besides the tholos, there was also in the court an altar of Zeus Herkeios or "protector of the enclosure". When all the suitors had fallen under the blows of Ulysses, the singer Phemios, who had chanced to escape the massacre, asked if he should embrace the knees of the conqueror, or if "leaving the megaron, he should go and seat himself against the altar of the great Zeus Herkios, where Laertes and Ulysses had burned in honor of the god the thighs of so many oxen".[1] It seems probable that t this altar was situated at about the middle of the court (Plate I, D). That is the position occupied at Tiryns. If it had been placed in the immediate vicinity of the principal building, t the smoke of the holocausts would have entered the vestibules and have penetrated into the megaron. Since the fire of the s sacrifice was kindled there, that altar was a sort of sink as at Tiryns and at Mycenae; it could only be a solid mass made of crude bricks or rather of stone. What the Greeks in the time of Homer understood by the "bomos" is comprehended, when one sees the poet apply this word to the plinths in the house of Alkinoos, that supported statues of young men in whose hands gleamed the torches.[2]

Note 1.p.86. Odyssey. XXII. 334-336.

Note 2.p.86. The same. VII. 100-101.

We have given to the house of Ulysses in its front and public portion an arrangement less complex than that characterizing the palace of the preceding age; we have placed there only a single vestibule open in front, like that giving access to the Greek temple, while at Mycenae and at Tiryns there was further behind that portico a closed antechamber, here having one of those three doors.[2] Nothing seems to us to justify the hypoth-

hypothesis of doubling the vestibule, of a closed room interposed between the megaron and the outer porch. This porch is what Homer calls the "prothyron", "what is before the door". (L). There is frequent mention in the two poems of the "aithousa"(implied "stoa"), verbally the "heater". We recognize this aithousa in the portico, wider than those of the two small sides of the court, that is attached to the main building, whose middle is occupied by the megaron (MM).[4] The term "prodomos","what is before the house", has a less precise sense; it is sometimes used as a synonym of prothyron, and sometimes it seems to apply to both the aithusa and the prothyron, to the whole of that front of the principal structure.[1] the Epithet that usually c characterizes the aithousa is "eridoupos" or sonorous; the noises of the court come to echo from the walls of the portico and against the under surface of its roof. In summer nights under that gallery men liked best to sleep, stretched on a mat or the skin of an animal.

Note 3.p.82. Histoire de l'Art. Vol. VI. Figs. 83, 116.

Note 4.p.86. The tale of the combat of Ulysses and Iros is thus explained very well. The fight occurred in the middle of the megaron; then after Ulysses has knocked down his adversary at the first blow, he dragged him outside; he passes through t the prothyron, the door that communicates with the aithousa, and goes to seat the vanquished against the wall of the court. (Odyssey. XVIII. 32-33). If in the phrase the court be mentioned before the aithusa and its doors, the measure of the verse caused this transposition; the mind of the hearer had no difficulty in reestablishing the real order and following the progress of Ulysses. From the vestibule he turns to right or left, doubtless toward the corner, and pushes Iros against the wall of the court. If one desired to see here in the aithousa a second vestibule placed before the prothyron, it must be supposed, that to relieve himself of Iros, Ulysses had to pass over the entire width of the court; with the interpretation proposed by us, he only has to take some steps after leaving the great hall. The connection of the two terms presents no difficulty whatever in a passage of the Iliad, where Phoenix relates why he was led to exile himself. (IX. 172-173). He is lying in the internal apartments, in the thalamos. One wishes to prevent his flight; so that he may not escape in the darkness, two fires are li-

one beneath the portico adjoining the vestibule, the other in the vestibule itself.

Note 1.p.87. Several passages of the Odyssey evidence this extended and collective sense generally of the word prodomos. (IV. 297, 302; III, 397, 399; XX, 1).

A single doorway opened from the prothyron (L) to the megaron (V). In the opening of that doorway, Ulysses came to seat himself humbly, when he presented himself to the suitors in the costume and appearance of a beggar;[2] that is guarded by Ulysses and his three companions during the entire duration of the combat.[3] That door has a threshold made of a block of ash and jambs of cypress wood, "that a carpenter has polished skilfully and dressed by rule".[4] By these details one feels the importance that the constructor attaches to this part of his work; he desires to first give to the visitors a high idea of the luxury of the royal habitation. The threshold of that opening, that sill of smooth ash, is the special threshold, passed by all visitors coming from outside; it is the great threshold (O).[5]

Note 2.p.87. Odyssey. XVII. 33.

Note 3.p.87. Odyssey. XXII. 75, 250.

Note 4.p.87. The same. XVII. 339-340.

Note 5.p.87. The same. XXII. 2. Jebb has demonstrated, that the great threshold over which Ulysses bounded at the beginning of canti XXII, could only be the threshold of the entrance doorway near the prothyron; we do not give that demonstration after him. (Journal. Vol. VII. p. 177-179). The entire sequence of the tale would be unintelligible, if one admits that Ulysses, after having bent his bow and sent his arrow to the mark from the back of the hall, crosses this hall as if to retreat. It is true that Homer says nothing of that step; but it is implied by the words that he places in the mouth of Ulysses speaking to Telemachus after accomplishing his exploit. (XXI. 424-430). It can be summarized thus:-- "I have arranged, Telmachus, for you not to blush for the guest to which you wished a good reception to be given; but the moment has come to leave these lords to their pleasures". He speaks these words in passing from the top to the bottom of the hall, as if to take leave; thus without arousing suspicion, he approaches the entrance of the megaron, and only after reaching his post of combat does he unmask and

lay the arrows at his feet. For hearers that knew the arrangement of the contemporary house, and to whom the theme of these tales was already familiar, there was no obscurity.

We have come to the megaron (V). One knows the vast dimensions of the hall for which has been recognized that appellation in the palaces of Tiryns and of Mycenae. It is unnecessary to seek dimensions in Homer; but it results from his tales, that the m megaron of Alkinoos and that of Ulysses are equally very spacious rooms. At Scheria, Alkinoos gathers in his palace to hear the story of the adventures of Ulysses all that he calls leaders and chiefs of the Pheacians. "The court and porticos and house were filled by the assembled men; there were many young and many old men".[1] At Ithaca all the suitors found places in the megaron of Ulysses, seated at ease around the festal tables; masters and servants, there were more than a hundred persons. As for the appearance of the hall, Homer nowhere defines it, but by more than one trait, one divines it to be very similar, at least in the entirety, to that given by us to the megaron in our restoration of the Mycenaean palace. The character of those interiors is indicated by the poet in a few verses; However rapid it may be, the sketch does not fail to have its color and effect. In the night preceding the supreme struggle, Telemachus and Ulysses cross the megaron to place in safety the arms in the apartments of the women, which the suitors might seize. Then Pallas illumines with sudden light the great room and Telemachus cries:--

Note 1.p.88. Odyssey. VIII. 56-57.

"O my father, a great marvel strikes my eyes!
Everywhere, on the walls of the hall and on the beautiful girders,
On the wooden joists of pine and on the columns raising their heads high,
There is in my eyes the splendor of blazing fire.
There is within here some one of the gods that inhabit the broad sky.[2]

Note 2.p.88. Odyssey. XIX. 36-40.

There is seen as if by lightning all presented by our restoration, the great walls offering a place ready prepared for the shining coatings and polished facings, the strong carpentry of the columns furnishing the necessary points of support.

These columns, whose height strikes the poet, have places kn known tc us. By the indications that Nausicaa gives to Ulysses, to tell him where to tell him where to find queen Arete in th e palace, one learns that these supports stand around the hearth.[1] There is no trace of a chimney in the buildings of the primitive age, and men were no farther advanced in the time of Homer. In speaking of the arms suspended on the walls of the megaron of Ulysses, he shows them soild by smoke, since their master was no longer there to clean them.[2] There was no part of the construction arranged to receive the smoke and to lead it outside; it eithe passed through a simple opening made in the roof over the fire, or through the spaces of the beams at the sides forming narrow dormers, and by the doorway, not without depositing a layer of soot during its passage. This is recalled by the epithet "aitnalois", that the poet applies to the ceilings of the palace of Priam, and those of the palace of Ulysses.[3] it means blackened by fire, smoked.

Note 1.p.89. Odyssey. VI. 305-307.

Note 2.p.89. The same. XVI. 287-290.

Note 3.p.89. Iliad. II, 414; Odyssey. XXII. 239.

At the time when the hearth was not placed against the wall, it could only be found in the middle of the hall (P); thus it was most accessible, and the heat was best distributed in the entire interior. I have very frequently seen it arranged in that fashion in Greece and in Turkey. I especially recall on the mountain of Samaria where we passed the night. The houses in which the peasants slept were only very low huts of earth; but there was at the middle of the village a great building containing a single very large room covered by a dome. This was called the "house for guests". (Medhafa). While the women worked in the fields, the chiefs of the families spent long hours there in smoking and talking. We found them gathered in their megaron at the end of the day; they gave us at first as bad a reception as the suitors formerly did to Ulysses. It was necessary for us to speak loud and boldly to lodge our beasts of burden in the corner of the great hall, and to obtain our places at the hearth, wet as we were by a torrent of rain. The hearth was formed of great stones ranged in a circle at the centre of the room; some logs were burning there, among the embers of which our supper was soon cooking. It is permissible to believe

that in the palace of Alkinoos and in that of Ulysses, the hearth had a less rustic appearance. That hearth was the centre around which clustered men to hear the poets sing, that in spite of the simplicity of their manners already had certain tastes for luxury; columns surrounded it, against which leaned seats decorated by inlays of ivory or of metal; it was necessarily in harmony with that entirety. Then as at Mycenae and at Tiryns, this must be a circular mass sufficiently raised above the ground, that one could place the fuel without stooping, a and wide enough that the brands should not roll off on the ground. Did they not at Mycenae carry their care so far as to paint in several colors the exterior of that base, so as to o place it in harmony with the rest of the decoration of the hall.[1]

Note 1.p.90. Histoire de l'Art. Vol. VI. p. 554-555. Fig. 247.

If one merely considers the open and public portion of the habitation, the analogy appears striking between the princely house, that the poet of the Odyssey had in view, and that made known by the excavations of Schliemann. The same court, the same great opening at the back of the wide vestibule; the same amplitude, the same arrangement of the megaron.

From the megaron we pass to the thalamos. This in the house of Ithaca has an upper story. Penelope during the absence of her husband occupied the second, as we have stated; she is several times seen to ascend and descend.[2] We have mentioned the beginnings of stairs at Mycenae, that attest the existence of the upper chambers;[3] we have also indicated here the starting of the stairs (3). Not there is the originality of the Homeric house; this is in the relation established between the two parts of the dwelling. With Ulysses the megaron and thalamos adjoin; passing from one to the other is continual. Numerous facts in the tale evidence that arrangement. Invited to Penelope, Ulysses crosses the megaron.[4] At night while lying in the vestibule, he sees the servant women leave the megaron to join the suitors to whom they have given themselves.[5] Penelope is seated in the ground story behind the rear wall of the megaron and hears what is said in that hall; she has placed her seat against the division wall.[1] In that wall is pierced a doorway opposite the entrance doorway; this is the one having a stone threshold, on which Ulysses places himself to shoot his arrow through the heads of the axes (2). This door is shut by Euryclea before the

battle, so that the suitors could not escape by that exit.[2] As soon as the struggle ends, Ulysses directs Telemachus to call Eurycles. He executes the order by shaking the door violently. Euryclea comes to look at the corpses;[3] then she leaves the megaron by the same route to bring in the faithless servants.[4] By that Penelope enters the megaron, when she has something to say to the suitors: the poet represents her as then standing upright near the jamb of the high opening.[5] She does act as did Arete in the palace, where the wife of Alkinoos is surrounded by the respect of all; she does not go to sit near the hearth; she does not mix with those men, whom she regards as enemies; she remains on the threshold as on a sort of neutral ground.

Note 2.p.90. Odyssey. XXI, 5; XXII, 1, 85 etc.

Note 3.p.90. Histoire de l'Art. Vol. VI. p. 351.

Note 4.p.90. Odyssey. XVII. 339, 505, 561-568.

Note 5.p.90. The same. XX. 6.

Note 1.p.91. The same. XX. 387-389.

Note 2.p.91. The same. XXI. 387.

Note 3.p.91. XXII. 399.

Note 4.p.91. The same. XXII. 433.

Note 5.p.91. The same. I, 333; XVIII, 209; XXI, 64.

If this doorway furnished the most rapid and most frequently used communication between the two quarters of the royal habitation, still it was not the only way that served for that use. The megaron yet had another exit; this is what Homer calls "orsothuse". This term is one of those not possessed by the classical language, and which already embarrassed the Alexdrine commentators; yet the poet is anxious to define the scene of the action, and explains himself clearly, so that one cannot hesitate concerning the sense of the word.

"There was an orsothure in the well built wall; near the threshold and placed at one end of the megaron on solid foundations was the passage leading into the corridor; it was closed by will joined planks; Ulysses commands the divine swineherd to guard that gate by staying near it: thus there was only a single front of attack.[6]

Note 6.p.91. Odyssey. XXII. 126-130. K. Reichel. L'orsothure dans le megaron homerique. (Archaeol. epigr. Mitt. aus Oesterreich-Ungarn. Vol. XVIII. 1895. p. 6-12).

The orsothure is a door that opens from the megaron into a corridor, and the threshold adjoining it cannot be the great threshold, that of the door of entrance, which is in the power of Ulysses and his companions, masters of the rear of the hall. This results from the appeal of one suitor to the others, and the reply that it caused.

"Friends", says Agileos, "will no one ascend to the orsothure? He will go to tell the people what occurs here, and immediately there will be outside only a cry; then that man will have shot his arrows for the last time".[1]

Note 1.p.92. Odyssey. XXII. 132-134.

Melanthios replies:- "Agileos, that cannot be done, for it is too near the beautiful doorway of the court, and the outlet of the corridor will be t o difficul to pass; one man, if valiant, could defend it alone against all".[2]

Note 2.p.92. Odyssey. XXII. 136-138.

One further learns from the expression employed by Agileos, that it is necessary to ascend several steps to gain the threshold of th orsothure (J); the floor of the corridor is then at a level higher than that of the great hall.

As for the corridor, it allowed the service of the private apartment without always having to cross the megaron under t the eyes of the guests occupying it. (T.T.T). It was placed against one of the side walls of the g eat hall. One end terminated in the court, since if one of the suitors could reach the corridor by the orsothure, it would have been easy for him to flee and reach the city. At the other end the corridor terminated at the thalamos. Homer did not need to specify it; he showed Eumeus following the steps of Melanthios into the interior of the quarter of the women;[3] now Eumeus could attem that pursuit only by passing through the orsothure, which was open to him. He goes by that route to load Melanthios with ba ds, and soon returns without any obstacle.

Note 3.p.92. Odyssey. XXII. 177-181.

What remains most difficult to comprehend are the movements of Melanthios. He has declared himself unable to flee by the orsothure, that Ulysses bars; but he has offered to the suitors, until then unarmed before their formidable enemy, to seek in the armory of Ulysses the helmets, shields and spears, that the latter had taken care on the previous evening to remove

the festal hall and to place in a safe location. To attain his ends, Melanthios ascends and then without difficulty reaches t the room in which are collected the arms.[1] The question is to know what must be understood by the "roges megarois.". The word roges is also one of the words not found in the later authors and is connected with the root from which is derived the Greek verb "regnymi" and the Latin verb "frangere"; to translate it literally it would signify the breaks of the megaron, but what that term really designates is unknown to us.

Note 1.p.93. Odyssey. XXII. 142-143.

Modern Greek in the northwest of Asia Minor appears to have retained the Homeric word roges in the form rouga with the sense of alley. It has then been proposed to see in the roges the corridors that enter the thalamos.[2] The connection is ingenious but where did Melanthios ascend to gain these passages? By the orsothure is replied; yet the lateral door is in the hands of Ulysses and his men. It is better to return to the explanation of the ancient commentators, who see in roges an equivalent of thyrides, small doors or windows. We have assumed in the megaron of women (R) a corbelled gallery over the threshold of polished stone (Q), a sort of balcony connecting the two lateral parts of the apartment of the women in the second story.[3] This passage is necessary for the service of the upper story, the gyneceum. We have admitted that in the wall at the height of the balcony were made two narrow openings, much higher than wide, that served for seeing from above without being seen, what occurred in the megaron of the men.[4] Those little windows could be closed by a light grille or a curtain. We assume Melanthios seeking to rise to the height of those windows. The agile goat-herd succeeded in placing a foot on the projection of the thick horizontal cross beams that held in place the vertical timbers forming the facing of the wall.[1] Once attaining the level of the balcony, he had only to move to one side to slide on one of those slopes and be landed on the balcony. From that moment he could go and come to the thalamos. Ulysses perceived nothing. The rear door was closed and all the back portion of the room was in darkness.[2]

Note 2.p.93. Jepp. The Homeric House. p. 182-183.

Note 3.p.93. This balcony is indicated in projection on the plan by a dotted line and by the letter d.

Note 4.p.93. Those windows would have been placed over the points o and b. That on the left is seen in the perspective view. (Plate II).

Note 1.p.94. Those cross beams are indicated on Plate II in the angle of the megaron that corresponds to the point o of the plan. Among the timbers that enter into the construction of the walls, yet others may present projections that would facilitate the climbing Melanthios.

Note 2.p.94. One might also suppose that this gallery overhung the megaron of the men; but he would be mistaken, that the women could pass in view of the men, and on the other hand, it would be necessary for Melanthios in reaching that balcony to perform a real feat, called in gymnastics a recovery.

It will perhaps be objected, that Melanthios being loaded by the arms that he brought, could not descend by the same way; but what prevents us from assuming that by the window he reaches spears and shields of the suitors, or throws them down from above? The relator does not draw up evidence; the insignificant details are suppressed and can be supplied by the imagination, to place in a stronger light the incidents that carry on the action.

With their upper story, the buildings situated behind the megaron must form a mass, whose height was nearly that of the great hall to which it forms a segment, but it certainly occupied a much larger area of ground. In that part of the palace were rooms in which the mistress of the house and her servants were engaged in domestic labors.[3] The principal one of those rooms was a sort of salon (R) placed behind the megaron of the men. It looked out on a little inner court (V), also furnished with a portico (X), around which was distributed all the dependences; it was very necessary that the women could sit in the open air to spin and sew. These courts have been found at Tiryns in what is believed to be the quarter of the women.

Note 3.p.94. This is what Homer sometimes calls "to megoron". Odyssey. XIX. 16.

The residence of the chief of the clan, heir and other chiefs, that the war had enriched and as we have stated, who was obliged to keep an open table, could not contain storerooms in which were preserved the valuable objects left by ancestors, and especiatty provisions for consumption. Here is how Homer describes

the more important of those stores:-

"Telemachus descended into the thalamos of his father, a large room with high ceiling, in which were heaped gold and bronze, vestments enclosed in coffers and much oil with good odor. There also stood jars of old and mild wine for drinking, jars filled with a pure liquid with a divine savor; they were there arranged beside each other against the wall in case Ulysses returned home, after having suffered so many misfortunes. The chamber was closed by a door made of well joined planks, by a door with two leaves. Night and day a guardian remained there, a woman, whose prudent mind watched over all that. This was Eurycles.

Note 1.p.95. Odyssey. II. 337-347.

This storeroom did not look out on the outer court; for its care was entrusted not to a man but to a woman, the old nurse of Ulysses, dean of the servant women. Besides, every time that Homer speaks of one of those treasuries, he calls it a thalamos; this suffices to indicate that these storerooms formed a part of the entirety designated by that term itself, when taken in its most extended sense. It seems that there were several of those stores with doors furnished with locks.[2] We distinguish at least two of them, that especially intended for daily provisions, and that in which were placed the arms. The first into which Telemachus descends must be a sort of cellar for better preserving the oil and wine; we have placed it under the room V, beside which are indicated on the plan two stairs, one by which to descend to that cellar, and the other of four steps to reach the chamber V. The perspective view shows the ventilators that furnish light and air to the cellar.

Note 2.p.95. Odyssey. XXI. 6-7, 45-[illegible].

The cellar contained with the jars, gold, bronze, and clothes folded in coffers; but it is not probable that arms were placed in a basement, where they would be exposed to rust. It would then not have been this cellar that was the storeroom.

"Where were preserved the treasures of the prince,
The bronze and the gold, and the well forged iron."[3]

Note 3.p.95. Odyssey. XXI. 9-10.

That where Penelope goes to take the bow of Ulysses, and where Telemachus had deposited the shields and swords that Te-

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The bronze and the gold, and the well forged iron."[3]

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That where Penelope goes to take the bow of Ulysses, and where Telemachus had deposited the shields and swords that We-

Melanthios removes. We shall seek that armory either in the room V situated over the cellar, or in the room Z; the latter is best suited by the epithet eschatos, the last or farthest place, by which the poet characterizes the chamber of which Penelope has the key;[1] it is indeed the chamber most distant from the entrance doorway. If Melanthios succeeded in entering it, this was because Telemachus neglected to close its door;[2] he was satisfied to push it.

Note 1.p.96. Odyssey. XXI. 8-9.

Note 2.p.96. The same. XXII. 154-156.

Likewise in that quarter at the very rear of the building m must be sought the nuptial chamber with its bed cut in the trunk of an olive tree with its roots remaining in the earth (Y).[3] That chamber, according to the description given by the poet, can only be in the ground story; in the immediate vicinity of this chamber, we assume two bathrooms (F F) for the use of the master of the house and the women.

Note 3.p.96. Odyssey. XXIII. 190-206.

To all that part of the house, access was only by the door opened at the back of the megaron (Q) and by the corridor (TT); but there must be in front and in connection with the entrance court, rooms as the natural dependances of the megaron. Such on the right are the bathrooms, frequently mentioned in Homer; we have placed three of them near the great hall (JJJ); those bathrooms could not be distant from the gynecium, for always t the servant women bathe the guests and rub them with oil. On the left may be assumed, entirely isolated from the habitation of the women, winter bedrooms for bachelors and transient guests. The bathrooms look on the corridor; the chambers for guests are reached by an irregular vestibule (I) with entrance under the portico.

How were the buildings of this princely residence covered? The poet neither states this for the house of Alkinoos nor for that of Ulysses; but there can be no doubt of the nature of th only roof mentioned by him. When Ulysses was with Circe, one o his companions was overcome by wine, and went to sleep on the roof; he fell from it and broke his neck.[4] That roof was certainly a terrace. Perhaps there were in some parts gable roofs; but those slopes could only have been very slight, whose inclination could never exceed that presented by the roofs of tem-

temple.[1] It further appears probable that at least all the of the large rooms of the princely habitations had terraces as coverings rather than gable roofs.[2]

Note A.p.98. Odyssey. XI. 72-75.

Note 1.p.97. It has been desired to find an allusion to the gabel roof in the passage of the Iliad (XXII. 710-712), where Homer desired to describe the attitude of the two wrestlers, that lean toward each other and have seized each other around the body, compares them to two timbers in carpentry, that he calls the "ameibontes" of the high house. In these ameibontes or opposed timbers, it is thought are recognized the principal rafters of a roof; but the idea could have the same propriety only if referred to a sharp roof, like that of our Gothic churches. Now nothing authorizes us to think that Grecian construction was ever crowned by a roof of that kind, and the comparison can be no longer understood for the very obtuse angle of the roof of a temple. It is necessary to believe that Homer had in mind there something else than a roof. One could conceive a wooden canopy placed over an opening pierced in the ceiling to allow the passage of the smoke. "It is", says the poet, "that to prevent the violence of the wind, the carpenter has fitted those opposing timbers; this last trait suits well the arrangement imagined by us, to prevent a squall from driving back the smoke in puffs into the interior.

Note 2.p.97. Histoire de l'Art. Vol. VI. p. 278-282.

When we described the Mycenaean palace, we frequently made use of Homer to take into account certain arrangements presented by the ruins of buildings, and likewise in the course of that study in which we sought to draw the plan of the house of Ithaca, we have on several occasions demanded information from the results of excavations made on the acropolises of Tiryns and of Mycenae. A comparison is made of the resemblances sufficiently numerous, and they are so striking, that it would be useless to insist more on this point. The type of the princely habitation that the poet had under his eyes, when he composed the Odyssey, was derived from that created by the Achaian princes in their castles in Argolis; both for the entirety and the details, it is a sketch from the same model.

Yet there are differences. The most important is in the plan, whose entire character it modifies.[2] At Tiryns, who is believ-

to be the private apartment is connected with the public part of the house only by complex passages and long turnings; at Ithaca there is continuity of the two quarters of the dwelling: there are direct communications between them, and consequently constant going and coming. Such a change in arrangement can be explained only by a change produced in the customs. Just as to become a vestment, the linen takes the dimensions and form of the body, so the house, that is also a covering and enclosure, adapts itself to the habits of the famil:. These regulate the arrangement of the habitation, in their diversity and according to time and place, these give a certain conformation, a certain appearance to it. If the internal arrangements of the palace of Tiryns have been well understood, that by the separation as established there between the two principal quarters of the residence recalled the Assyrian palace, it had its harem. Among the people that built it, customs were nearly those of the Orient, at least in the upper class, among the nobles and kings; women there lived sheltered from the eyes and the society of o men. The Achaian princes must have been polygamous. Between their time and that of Homer, Grecian society made a great advance; monogamy triumphed. As wife and mother, woman has assumed an important place in the family, a place that she will always retain. The part played by her in the epic period is more important and more honorable than that to which she will be r reduced in the Athens of the 5 th and 4 th centuries. Helen at Troy on the platform of the tower, where are gathered the old men, Helen again at Sparta in her palace, Arete among the Phaeacians, Penelope at Ithaca, without embarrasment show themselves even to strangers, come to sit in the midst of men and speak to them. In these acts they are as free from intrigue as a Roman matron or a French woman of today. Being given that position of woman, the architect when laying the foundations of the house could not have the idea of trying to separate the sexes, and of multiplying barriers between them. While not sacrificing the requirements of domestic life to those of social life, he sought to render the relations easy and rapid between those, that were placed in contact by so many common interests and so many occasions of meeting.

Note 3.p.97. These differences have been well emphasized by Percy Gardner; New Chapters in Greek History. p. 145-150.

As an expression of more advanced morality, the Homeric house is then superior to the Mycenaean house; but is it the same in regard to amplitude and richness? The buildings could not occupy such a great extent of ground, where the two quarters of the house adjoined each other, as where must be reserved marked intervals between them. Thus the entirety of the edifices of the Homeric age acquired a more connected appearance, less picturesque and less varied. The palace of Tiryns had two wide courts before the megaron; there were other smaller ones in the quarter of the women between the buildings. Those courts were connected; red and blue bands were traced with the brush on the pavement of small pebbles, and gave it an appearance of a many colored rug.[1] It does not appear that the attempt was carried so far as at Troy or Ithaca; if the great court is partly paved, and an altar is erected, the pile of manure found there made it resemble our farm courts in a certain degree. The interior of the megaron was no better kept. One does not conceive a border of alabaster slabs, as at Mycenae, in that hall were prepared the foods, where the meat was cooked on the fire, where there lay on the ground the bones and skins of the oxen and sheep, that had furnished the materials of recent repasts.[2] With the smoke from the burning wood were mingled the vapors and odors of the grease running into the fire, an odor that offends our nostrils today, but which charmed those of the contemporaries of Homer, in memory of the free feast recalled to them by it;[3] they found so much pleasure in it, that they a assumed the same taste in their gods.[4] It is possible that among the Achaian princes, the cooking did not occur thus in the megaron; the smoke has left no traces on the fragments of painted plaster collected at Tiryns and at Mycenae. Men did not extend over all surfaces the covering by painting to expose it to disappear in brief time beneath a coating of greasy soot. We have stated how the Mycenaean architect was able to obtain this result; we have assumed at the centre of the ceiling a sort of lantern furnished with side openings through which the smoke escaped, carried by a strong current of air.[5] The house known to Homer also had openings in the roof arranged for that purpose; but what is certain, is that the arrangement given to the orifice did not prevent the smoke from blackening certain part of the carpentry.

Note 1.p.99. Histoire de l'Art. Vol. VI. p.288.

Note 2.p.99. The same. Vol. VI.p.288; Odyssey. XX. 299-300, 383-364.

Note 3.p.99. Iliad. VIII. 549-550; Odyssey. X, 10; XII, 369.

Note 4.p.99. Iliad. I, 66; IV, 49; VIII, 549-551, etc.

Note 5.p.99. Histoire de l'Art. Vol. VI. p. 693-694. Pl. XI.

These comparisons leave the impression, that the house of Ithaca, if another Schliemann should find its site and uncover its remains, would have a small and mean appearance in comparison with what must have been the palaces of Tiryns and of Mycenae, such as their ruins have allowed us to restore them.

This inferiority of the later of the two types is again due to other causes. Chiefs of bands that scoured the seas, pillaged Egypt and had taken Troy, holders of an enormous quantity of the precious metals, possessors of vast lands that slaves cultivated for them, the sovereigns of Orchomenos and of Mycenae placed at the disposal of the architect and his assistants resources very different from what the richest nobles could do in the cities of Ionia, where the royal authority decreased, and where already arose the republican spirit. Thus is divined in the dwellings of Achaian princes, a seeking for the effect and luxury no longer known to the contemporaries of the poet. There does not seem to have been in the house of Alkinoos or that of Ulysses anything resembling either the double propylaea, that the visitor finds before him when he enters the palace of Tiryns, or that broad ramp by which he ascends to that of Mycenae. All in those two palaces, the courts, megaron and principal rooms of the apartment of the women, must be more spacious and more decorated than in the house of Ithaca, where with the eddies of smoke filling the hall, men could not even think of the use of those frescos, that were the ornament of the Mycenaean house. Also there is nowhere the least mention of decoration applied with the brush on the surfaces of the edifices. There is no longer any question in regard to the residence of A,kinoos, that fairy palace, than concerning that of Ulysses, which is an exact copy o habitations of lords, where were seated more than once as dear and desired guests, the epic poets by whom were traced the first sketches of the epic period.

If in the halls where they celebrated the exploits of ancestors, those singers had had under their eyes paintings of war

of the chase, like those presented to the eyes on the walls of the palaces of Tiryns and of Mycenae, artificial forms of the kind of those on the internal walls of those buildings, enclosed within fanciful scrolls of spirals and among the foliage of marine plants, there would have been every chance for us to ha have been informed of it by some significant epithet or by some trait in comparison. For example, is there a motive better made for striking the imagination, and that lends itself better to allusion or description, than that of great winged , of sphynxes with mitred heads and floating plumes, whose broad wings tinted red and blue, cover with their variegated plumage the walls of one of those halls of Tiryns? [1] To explain the silence of the poet on that subject, it must be admitted that between the time when Mycenae flourished and that when the epic period closed, the art of decorative painting had fallen into complete disuse. This appears to be confirmed by the epithets by which the poet defines the appearance of the rooms of the house; What he recalls is always the polish of the brilliant surface. He does not state whether that is made of wood or a plastering applied to the wall. In the last case, the sole result that the workman sought to attain, when he laid the coating was to smo the surface wall. Homer never employs on that occasion the wo "poicnilos" or varicolored, and of which he makes such frequent u use concerning fabrics. [2] Perhaps also, and this supposition is very reasonable, thin slabs of stone were carefully cut with polished surfaces, and covered parts of the wall, occupying the surfaces between the timbers separating the courses of bricks. We have adopted an arrangement of that kind for the wal of the prothyron of the palace shown in the perspective view. [3]

Note 1.p.101. Schliemann. Tiryns. Plates VI, VII.

Note 2.p.101. (Greek). Odyssey. XVI, 449; XVIII, 206; XIX, 600, etc.

Note 3.p.101. This facing would be analogous to that whose remains have been found by Dörpfeld in certain parts of the palace of Mycenae. (Histoire de l'Art. Vol. VI. Figs. 177, 31', p. 715.

On the other hand, the tradition has not been lost of another art, which was much cultivated in the course of the Mycenaean period; we wish to speak of the processes by which are appli on stone or wood, metal cut out in very thin leaves, or ind

were overlaid with precious materials like ivory and enameled faience. It is said in the Iliad, that the house of Poseidon is of gold, and that of Hephaestos is of bronze.[1] It is known what should be understood by these words "chryseos" and "chalcheos"; there is concerned a facing made of plates of gold or of bronze; but the habitations so qualified are not princely houses, these are the imaginary palaces of the immortal gods. All that the poet knows of the palace of Priam is, that it is built of stones well faced. It would then be permitted to believe that the poet, to give a higher idea of the splendor with which shone those divine edifices, has lent to them a sort of decoration, whose use left memories, and of which perhaps existed some remains in old monuments; the great funerary dome of Mycenae could not have then lost all its bronze stars. Yet from the Odyssey it would seem, that the taste for these overlays had remained, that there were still workmen skilful in laying metal on a ground, and in inlaying therein, cut into thin slices, precious materials of varied colors. That sort of decoration the poet had in view when he placed these words in the mouth of Telemachus, who is seized with admiration on seeing the palace of Menelaus:-

"Son of Nestor, dear to my heart, view
The splendor of the bronze in the sonorous house,
And that of gold, of electron, of silver and ivory."[1]

Note 1.p.102. Odyssey. IV. 71-73. We do not think it doubtful that the genitive "plektron" belongs to the masculine noun "plektros", that designates a natural alloy of gold and silver, and not to the neuter noun "plekhon", amber. Amber rarely exists except in small pieces, and we do not see how it would be applied to the decoration of large surfaces; but it is especially necessary to note the place occupied here by that word. The material that it represents is named between gold and silver; nothing is more natural than to refer to a metal partaking of both, as its pale yellow tint is midway between the red gleam of gold and the whiteness of silver.

The same ornamentation is still more sumptuous in the palace of Alkinoos, of which the poet wished to make something superior to whatever most beautiful had been seen by his hearers, who had traveled most over the world:--

"Walls of brass had been erected in all parts,

From threshold to back; all around extended a frieze of "kyanos";
Doors of gold prevented access to the well closed house;
Jambs of silver stood on the threshold of bronze;
The lintel was of gold, and of gold was also the cyma".[2]

Note 2.p.102. Odyssey. VII. 86-90.

By multiplying details, Homer seeks to give here a feeling of being dazzled; as many architectural members, so many mirrors, each reflecting rays of a different color. Doubtless nowhere was a house of a prince, where the different parts of the edifice were all equally resplendent; but those to whom were addressed these tales, would not have had the vision, that the narrator desired to suggest, if they had never seen anything similar to those shining coverings of metal.

Also only in the palace of Alkinoos does one see appear beside metal, as a decorative element a material that plays there the same part as ivory in the palace of Menelaus, that kyanos, in which has been recognized the blue enamels, that Egypt and Phoenicia made and exported in great quantity.[1] Ivory and that vitrified paste served to mix with the warm reflections of metal of the softest and most vivid tones, one with its milky yellow and the other the freshness of its blue. This mention of kyanos is unique in the epic period, and it is found in reference to the palace of Alkinoos; one can infer from it that this faience, an exotic product, was more rare and costly than ivory.

Note 1.p.103. Histoire de l'Art. Vol. VI. p. 559-560.

If the princely house of the Homeric age does no seem to have equaled that of the primitive age either by the amplitude of i its mass, by the convenience of its arrangement, or by the richness and elegance of its decoration, it was no less the edifice to which was devoted the principal efforts of the architect, during the period corresponding to the formation and completion of the epic period. For various reasons, the tomb did not then take the same development as in the preceding centuries; being entirely subterranean and attracting attention only by a stele without figures or inscription, it has left only slight traces. Those which I have found very careful and very ornate at Athens have above ground only a slightly marked relief; their arrangement remains very simple. As for religious architecture, it still remains in infancy. The temple has only a moderate importance, being lost in the vast extent of the sacred enclosure,

among the altars and trees that surround it. This must be so while there continued to predominate the power of the chief of the clan, the hereditary prince. The temple will increase, and all the arts will be applied together to embellish and to ornament it with their best, only on the day when the city is composed of equals, and will have no other master than the god, whose good will must ensure the success of all its enterprises. From that moment, its constant preoccupation and its passion will be to erect in honor of that god an edifice, that by its dimensions and by its nobility may be worthy of the power and majesty, that it attributes to its divine protector. It is then that, as we have the proof for Mycenae, Tiryns and Athens, temples will replace palaces, will arise on even the ruins of the royal habitations, where reigned dynasties long since vanished; to build and ornament them, each city small or great, jealous to excel its neighbors and rivals, will consecrate all resources at its disposal, in capital and in talents. The revolution that substitutes everywhere republics for the ancient monarchies co coinciding with the flight of every sense, after the appearance and diffusion of the epic period, taken by the soul of the Hellenic race, it will result, that during the period in which that people attains its maturity, the temple will be the masterpiece of the formative genius of Greece.

Chapter III. Sculpture.

There remains scarcely any work of sculpture, that one has serious reasons for attributing to the two or three centuries, that succeeded the Dorian invasion. Excavations have supplied but very few monuments, that can be assigned with some probability to that period. The epic poem is the sole document from which one is authorized to inquire, what could then be produced by art and industry. Now those poems maintain on the subject of sculpture a silence, that suffices to indicate how little that branch of form was developed among the people and in the time, when lived the authors of the Iliad and Odyssey.

Among the sentiments which the sculptor labors to satisfy by the procedure of statuary in the round or by that in relief, there is none known to contemporaries of Homer. The poets then began to personify their gods, to define them by an entirety of traits, which for each of the immortals varied according to the character of the part assigned to it by the work of thought. When Homer places on the scene one of the divinities of Olympos, he sees it there, and by the epithets by which he qualifies it, his hearers also see it with the eyes of the mind, in the originality of its individual appearance; they see Zeus differently from Poseidon, and Apollo other than Hermes. Between one and another, excepting in sex, everything differs, age and stature, arrangement of the hair, expression of the face, pose and gesture. It is the same for the goddesses. They are all represented as beautiful as the most beautiful daughters of Greece; but not to all are given the same style of beauty. This one, Aphrodite, is seen to be blonde, adorned with the freshness and graces of youth in its first flower. That one, Hera, has the port of a brunette and proud matron, whose body has given sons to Zeus without maternity having changed in her the nobility of contour; she has only to show herself in the meadows of Ida, for passions to awake at once in the heart of her immortal spouse. The huntress Artemis, who pursues wild animals in the forests, and whose unfailing arrows also give death to men, does not resemble Athena, the inspirer of wise designs and courageous acts, the protectress and counselor of Ulysses, the most crafty of heros.

The Ionian epic poet and the Greeks that listened to him thus have thenceforth a clear vision of the divine types, whose ch-

outlines are very decided; but the moment has not come, when t the artist will be capable of giving a body of clay, marble or bronze to the personages, that the poet has brought forth. The latter has found in the treasury of an idiom marvellously rich and flexible, resources that have permitted him to sketch those figures, to make them sufficiently definite for the imagination to perceive them as living beings, each one with the peculiarities that distinguish them. On the other hand, art cannot advance at the same pace as poetry; to realize its conceptions, the latter employs the words of the language; now these words are the first and most spontaneous of the creations of the intelligence. All vibrant still, among a people youthful, impressions received by them in contact with nature by the senses, they respond as a multitude to the appeal of the poet. he has need of new words to express a novel idea, to render a feeling not previously expressed; he derives them with sovereign freedom from the inexhaustible stock of roots at his disposal; the procedures of derivation and composition give him every facility in that respect. Those words, that he has gathered from t the lips of men, and those that he has invented when the current vocabulary no longer suffices him, seem hurried to produce themselves outside. Docile to the internal voice that evokes and creates them as the thought is born, they come of themselves to group themselves according to their natural affinities, and to assume in the phrase of the verse the place most appropriate for them.

It does not proceed the same, when this[13] no longer by means of winged words, to take the Homeric phrase, that the types are formed, but one is restricted to seek the contour in the material, to disengage it by the work of the hand. Like an unfailing spring, language gushes forth from even the profound depths of the soul; when this is animated and heated, it paints in the colors of passion, almost unconsciously. the mind, so to speak, has no consciousness of the secret effect by which it obtains the desired result. The material itself is the non-me, as the philosophers say. Man does not act directly on it; between the material and him is in intermediary, the tool, that requires a long apprenticeship. The first attempts made to employ it for the expression of an idea are resisted by the material; when this is stone, it defends itself by its hardness, that

does not allow itself to be cut until the time when one knows how to temper and sharpen the tool of bronze or of iron; if it be clay, it is worked even by its softness, but is poorly adapted to faithfully retain the impress of a form, before the oven of the potter is heated. To utilize metal, it is necessary to know how to reduce it to thin sheets, that are modeled by the hammer, or to melt and cast it in a mould. Another difficulty in sculpture is that it can only represent objects under the condition of certain sacrifices and by means of certain conventions. Painting and drawing deceive bodies of [illegible], that these arts only endeavor to recall by the indication of t the cast shadows. In the relief, this thickness is sensibly reduced; the different planes are thinned and are applied on each other. The figure in the round is not an exact reproduction of the reality. When one does not suppress its color, he is led to simplify it so much, that it becomes arbitrary and purely decorative. Only at the price of long experiments do even the best endowed peoples attain to the mastery of the procedures of execution, and to adopt modes of representation that permit the observer to reestablish by rapid intuition the true relations, those that the artist proposed to suggest to the mind.

That sculpture should be so greatly behind poetry should not astonish one. Not the sculptor furnished to the epic poet those figures of gods and goddesses to which he gives such a personal character. In his time it seems that the divinity had almost no statues in the sanctuaries of Greece. Nowhere in the Odyssey is a mention of a statue placed in a temple. Yet if men then had had the habit of placing those images in places of worship, Homer would have found more than on occasion of speaking of this. When he relates the return of Ulysses to Ithaca, he describes the sanctuary of the nymphs in which the hero stays with Eumeus before entering the city; he describes the top of the rock from which falls the fountain, the basin that receives it, the wood of alders that surrounds the sacred fountain by its shade, and finally the altar to which all persons bring their offerings. If there had been a temple that enclosed the images of the nymphs, that would have found a place in his description. An edifice, a group of figures, would be details that would modify too much the character of the whole, for it to be possible to pass over them in silence.[1]

Note 1.p.108. Odyssey. XVII. 205-211.

In the Iliad we see one temple statue appear, but only one, that of the Trojan Athena. The poet mentions that idol several times in one of those parts of the poem, that the boldest critics scarcely dare to term a later interpolation in the sixth canto.[2] At the prayer of Hector, Hecuba goes to place on the knees of Athena a richly embroidered peplum to soften her anger, which presumes a seated figure, a posture of which more than one example is presented to us by the archaic images of the goddess; it is sufficient to recall here the Athena of Endoios.

Note 2.p.108. Iliad. VI. 90, 273, 302.

Was the idol of Ilios of wood or stone? The poet gives no indication on that point. The work might be very rude, almost as barbaric as certain terra cottas of Mycenae or of Tiryns;[3] religious sentiment is always less attached to the form than to the idea. One sees it, even in the centuries where an art has already advanced to develop the esthetic feeling, remain faithful frequently to old and rude images, provided that they had been consecrated and as it were, deified by the veneration of preceding generations. What would tend to cause to be believed, that there existed from that time in the sanctuaries a certain number of these seated figures, are the epithets "on the beautiful throne, on the golden throne", that poetry attributes to several goddesses, for example to Eos, Hera and Artemis; the last of these phrases is explained by the habit of o overlaying sheets of metal on certain parts of the seats on which those idols sat. By this display of luxury was compensated the poverty of design of the figure. Further even the formless statues must be the exception. There is mentioned in the epic period more than one sanctuary, that of Zeus on Ida,[4], that of the Paphian Apollo,[5], that of the Delian Apollo,[6], and that of the Sperchios among the Myrmidons.[7] The poet does not forget to recall in that connection the existence of an altar, from which ascends the smoke of the sacrifices; he says not a word of the image.

Note 3.p.108. Histoire de l'Art. Vol. VI. Chap. IX. Sect. 2.

Note 4.p.108. Iliad. VIII. 47.

Note 5.p.108. Odyssey. VIII. p.363.

Note 6.p.108. The same. VIII. p. 162-163.

Note 7.p.108. Iliad. XXII. 148.

The divinity must have been represented at that epoch in most sanctuaries only by rough stones, raised stones. Those at the origin were only pieces or quarters of a rock untouched by a tool. The instinct of the symmetry had gradually led to cut them and to give them definite forms, that of a slab, a cylindrical or rectangular shaft; then when under the influence of poetry, minds accustomed themselves to conceive the gods as men like those alive on earth, but more beautiful and larger than them, the hand of the workman endeavored more or less awkwardly to express that conception. Without pretending at first to imitate nature, it sketched on stone the head and members of man, summary indications that must in time lead to the creation of the statue. In its most ancient types, that still retains an appearance that allows the primitive forms to be divined; in studying archaic art, we meet with the stele, pier and column statues.

Men were not yet there in the age when the epic period flourished; the patient labor that disengaged the statue from the rough stone had scarcely commenced. The statue was still found very rudely sketched, except in some cities more advanced, perhaps by having seen images of Asian origin and having sought to imitate them. The epic period is not absolutely ignorant of the existence of idol guests and mistresses of a temple; but on the other hand, it only mentions them in all, but a single and only time.

If then the art was not yet able to multiply statues, which their stature and weight made immovable in the sanctuaries, it would have been easier to fashion portable figures, made in their reduced dimensions to accompany the family in its emigrations, the warrior to battle and the dead to the tomb. The sepulchres of the primitive period have furnished many of those statuettes, some of terra cotta, others of stone, some of gold or bronze; in most of them the form is scarcely indicated. It seems difficult to believe that the Aeolians and the Ionians, for whom the epic poets sang, were not capable of modeling idols of such summary execution. Yet there is not in Homer a single word relating to images of that kind. These appear neither in the tales of voyages, in the scenes of combat, nor in the description of funeral rites. Still it is not probable, ... during two or three centuries, there was abandoned and interr...

a custom, which we have found established everywhere in the c course of the preceding age, and that we shall see reappear d during the entire duration of the classical age. What is deceptive, is that one is always inclined to imagine Homeric poetry to be a mirror in which is reflected, without losing a single one, all the traits of the contemporaneous reality. Now it is far from being so, we have already had occasion to state this in regard to funerary rites. The same remark applies to the r religion: if one judges it only by the epic period, Greece would not then have had other gods than the great gods of Olympus. In the Iliad and the Odyssey are but few allusions to that worship of the inferior gods, gods of pastures and of grottos, of fountains and of forests, nameless and obscure demons, that is a remnant of primitive feticnism, and that has never lost its hold on the souls. This is on the one hand, tha the epic period represents an ideal, which has been conceived by the poets. The poets are for that time, what the philosophers will be later; they are distinguished from the multitude by a greater power of reflection, by a superior power of abstraction' their thoughts are in advance of those of the men among whom they live. On the other hand, posterity has preserved but a very small part of the songs that charmed the infancy of Greece. The poems that we possess assume this, seeing many others, that were neve collected in writing, while those that were so before they had been lost to memory, all with bu two exceptions have disappeared in the work of antiquity. The Iliad and Odyssey alone remain. Those poems were born in Asian Greece, whose ideas and customs were not at all those of the inhabitants of European Greece; one would then err in pretending to seek there a complete picture of the life of the Grecian people in its entirety. Further, even for the group of the tribes to which we owe the completion of the epic period, that does not give what men have sometimes claimed to find there, a representation of their moral and social condition that comprises neither deformation nor omission. The poets have a very clear perception of the distance separating the society in which they lived from that marvellous and distant world in which their imagination had chosen a home; they did in their fashion what a learned poet would do todan. A secret instinct warned them that this world of gods and heros could not be an exact copy of the

in which, for them and their hearers unrolled the uniform course of daily existence; to furnish the scene in which they placed their personages, they have utilized wha they had under their eyes, but only taking from that present which inspired only t the elements not at variance with the idea, that they had formed of the past. This was the sole means that they had for giving to their tales surroundings to correspond to the singularity of the adventures of a Ulysses, with the almost superhuman character and the prowess of a Hector, an Ajax and an Achilles, with the perpetual intervention of the divinity in the quarrels of men.

Finally, if there is no mention in Homer of a certain custom, that there is reason to believe very ancient, one can yet explain that silence by another consideration. How in two poems wi with very definite subjects and limited extent, Homer could hav found materials for treating and rendering all the aspects of the life of his people, of a life already complex? The action of the Iliad develops entirely in a besieged city, in the camp and on a field of battle. That of the Odyssey is more varied; yet it does not exhaust the diversity of the situations in which the Greek of that time could find himself thrown by the accidents of his fate. Thus one comprehends that certain forms of religion and of art, certain procedures in industry, certai peculiarities and customs have left no traces in the epic period; Homer has not spoken of them, because he had no occasion to do so. It is perhaps for that reason that the epic period is silent on the subject of those clay figurines, tha have come from Mycenaean tombs in such great numbers, and whose manufacture must have continued, at least where the rite of interment persisted. One divines how the poet was led to appear ignorant even of the existence of those rude images. If the obsequies of his heros were celebrated according to the same rites as were formerly at Mycenae those of the Achaian kings, he would have described the funerary equipment; those idols could have found themselves included thus in the enumeration of the objects received by the tomb; but in the rite of cremation as presented by him, all that the survivor confide to the earth is a handful of calcined bones contained in a metal vase; there is no place for the images of the tutelary divinities in that small receiver and in the hole enclosing it

in the base of the tumulus. Likewise also there is no reason to be astonished, if in the danger of combat or that of the sea, it is to Zeus or Apollo, to Poseidon or Athena, that the heros address their despairing or grateful prayers. The gods respond to that appeal by leaving Olympus to come to snatch their proteges from the steel of the enemy or the rage of the waves, a and the impassioned dialogue arising thus between the gods and their favorite children indeed has a grandeur differing from a few words murmured in a low voice before a mean annulet. The epic poet does not see the gods otherwise than with the noble and pure traits lent to them in his thought. Almost formless statues, th only ones that men knew how to produce then, did not correspond to the ideal that he conceived. His eyes were not fixed on them; he voluntarily forgot and seemed to disdain them.

The true and only sculptor is then the poet' the material in which he models the types, that he left to the sculptor of the future, is the language, that language both artless and learned, that while retaining the freshness of the vivid emotions of youth, consists of elements borrowed from different dialects, and is already in all the force of the term, a work of art. To impress on the human form such a character of beauty, that it arouses in the soul the sentiment of the divine, is an undertaking that the sculptor is not yet in condition to attempt; he is satisfied by the role of decorator; the living form, that of man or of the animal, supplies him with motives for ornamenting the house and the furniture that equips it. There was a role already undertaken by the Mycenaean artisan, that the emigrants could not have failed to bring with them into Asia Minor some skilful workmen, trained to employ the procedures and the motives utilized by the industry of the Achaian age. Were the contemporaries of Homer especially inspired by the ancient models of the national art, or indeed did they demand by preference lessons from the objects of luxury fabricated in Egypt and Phoenicia, which came to them by Cyprus and Rhodes? The monuments having disappeared, it is difficult to state exactly the style of the artists, whose works attracted the attention of the poet. It is probable, that if they had been found, one would find there the trace of that twofold influence. More than one passage of epic poetry evidences the relations of the Greeks

maintained with the Phoenicians; the Ionian workmen could not remain indifferent to the examples given him by the men of Tyre and Sidon, those industrious pupils of Egypt.

The works mentioned in the epic poets could not all have had the same character. Some were connected by their workmanship with the traditions of Mycenaean art; what dominated in the o others was the more or less direct imitation of the types furnished by Phoenician industry. Among the rare objects that the poet mentioned to his hearers as worthy of admiration, one cannot truly divine which of the two styles they more particularly bore the impress, the national or the Asian style.

The question is not proposed even for those followers of Hephaestos, who lend to the lame divinity the aid of their shoulder, when he crosses his shop, for those statues of gold, "that resemble living young girls with intelligence and thought, voice and strength, who know the works of the immortal gods".[1] One is here in the empire of fancy. The poet has seen nothing like those golden virgins, that walk and speak; they are daughters of his imagination. All is lavished around Hephaestos. The tripods that he has fashioned are in motion, even accompanying him to Olympus and return with him.[2] At the sign of the master, the bellows swells and empties itself to make the flame rise.[3] Those marvellous servants make one think of the bulls with brazen feet, emitting fire from their nostrils, that in the myth of the Argonauts, the same Hephaestos sent as a gift to Aetes, king of Colchis.

Note 1.p.113. Iliad. XVIII. 417-420.

Note 2.p.113. Some. XVII. 374-377.

Note 3.p.113. Some. XVIII. 468-473.

Quite otherwise is the case of the figures of young men, that in the palace of Alkinoos hold in their hands lighted torches and illuminate the festal hall.[4] The object there described by Homer, he has found on his way or has heard it mentioned. That is what permits him to state as a significant detail, the "well cut plinths", on which are placed these statues. Those would be of gold, if one takes literally the word defining the material; but one should not forget that the poet is not an appraiser. He sees only the appearance, and what he proposes is to arouse the sensation of seeing. When he says gold, we must understand gilded bronze. Nowhere in Greece was gold ever as abundant as

in prehistoric Mycenae, and likewise have not been found figures, either executed in solid gold or composed of sheets of gold, whose dimensions are comparable to those supporters of torches; to fulfil their office, these must approach at least what is c called semi-natural. Besides, the epic language often attaches the epithets "gold" or "silver" to members of the edifice, that like the walls of a hall or the architrave of a doorway, cannot have been made of this precious metals, but on which were nailed, sometimes on the stone and sometimes on wood, plates of b bronze covered by leaves of gold or silver.[1]

Note 4.p.113. Odyssey. VII. 100-103.

Note 1.p.114. Histoire de l'Art. Vol. VII. p. 101.

As for the motive itself of these images, there is nothing to surprise us. From the highest antiquity Egypt caused the human figure to enter into the composition of its furniture; we have seen it utilizedthus in the handles of spoons and in arm chairs, where it supports the arms of the seat.[2] The same use of it was made at Mycenae in the handles of mirrors.[3] This type of torch-bearer, for which the modern decorator has a m marked preference (see the bronze statues surrounding the Opera of Paris) is not represented in the classical art of Greece; but it was familiar to archaic art; it is found in the paintings of Etruscan tombs and among the bronzes taken from those sepulchres.[4]

Note 2.p.114. Histoire de l'Art. Vol. I. p. 582, 583, 585, 58?.

Note 3.p.114. Histoire de l'Art. Vol. VI. Figs. 386,387,388.

Note 4.p.114. Helbig. L'epopee homerique. p. 505.

These are again figures of wood or of silvered and gilded br bronze, that we divine in those dogs, "forever immortal and exempt from old age", that were fashioned by the wise art of Hephaestos and watch over this same palace, placed at both sides of the doorway.[5] What we have found everywhere in the Orient at that place are factitious animals, such as the sphynx, griffin, bull or winged lion. The lion must have owed to his strength and to the fear inspired by him, the honor of being invested with that function in his natural form. We have seen in Phrygia rampan lions standing beside the doorways of rock tombs;[6] we hav seen them at Mycenae in the same position, surmounting the lintel of the gate at the entrance of the citadel. The poet alludes to a different mode of grouping. He evidently

represents to himself these guardians of the house as crouching or lying at right and left of the threshold, like the sphynxes before the temples of Egypt. What is original in that arrangement is the mode of substituting the dog, that humble companion of man either for the lion, the king of the wild beasts, or for all those composite monsters, in whom are contained traits, whose assemblage arouses the idea of an extraordinary and mysterious power. Is it not necessary to see there the effect of the innate tendencies of the Greek genius, of those revealed by the later manifestations of sculpture? The poet confides the guard of the house to the dog, and not to the sphynx or the griffin, because he has the taste for the simple and true; he has seen the dog in that place and that office.[1]

Note 5.p.114. Odyssey. VII. 91-94.

Note 6.p.114. Histoire de l'Art. Vol. V. Figs., 64, 65.

Note 7.p.114. The same. Vol. VI. plate 14.

Note 1.p.115. M. Helbig has made a conjecture in this connection, that appears to us more ingenious than probable.(L'epopee homerique. p. 498). He states that the Homeric language does not possess the words "sphynx and gryph", by which were later designated the sphynx and the griffin. Since the study of the Mycenaean monuments has proved to him that these exotic types were known by the Greeks much before the Homeric age, he asks whether in the lack of special terms, they did not then employ the word "chyon" to designate all these monsters invented by the Orient, and what suggests that hypothesis to him is, that he finds in the tragic poets of Athens examples of thes sense attributed to the word chyon; but what he forgets is, that in the two texts of Eschylus and of Sophocles to which he refers, and where the sphynx is called chyon, this word is explained here by the word "sphynx", that precedes it in t the same verse, and there by the epithet "rhapsodos"; all obscurity is thus avoided. If Homer had in view here the sphynx or griffin, it would have been easy for him als to have characterized those guardians by some significant epithet, that would have warned his hearers, that not ordinary dogs watched at the doorway of the palace of Alkinoos.

Those torch-bearers and dogs were there purely ornamental figures, that merely served to equip the palace of Alkinoos. It is not the same with a type to which the poet alludes on several

occasions, that of the Gorgon, i.e., the head of a woman, that by the character of her features was destined to cast terror into the souls that saw her. That type had thenceforth the expressive value that it has always retained.[2] That head was figured on the border of the shield of Agamemnon, and as a central ornament on the breastplate of Athena. This was "the Gorgon with the menacing eyes and the terrible look"; it was the terrible and frightful head of the formidable monster, insignia of Zeus who wears the breastplate".[4] With the Gorgon Homer associates in the shield Fear and Terror, on the breastplate Discord, Valor and Flight, so many abstractions that assume form only in the mind of the poet. The only ones that Greek sculpture seems to have personified, and yet has done so very rarely, are Phobos and Deimos.[5] On the contrary, very numerous monuments attest that the popularity of the Gorgon type never ceased. Archaic art frequently employed it, and tradition carried it back to the remote period to which are attributed the walls of Tiryns. Pausanias saw at Argos a head of the Gorgon in stone, that passed for a work of the Cyclops.[1]

Note 2.p.115. On the subject of the representations of the Gorgon, see the very systematic and very complete list drawn up by M. Jean Six:-- De Gorgone. pp. 100 + 2 pls. Amsterdam. 1885. The Homeric texts are studied there. p. 78-80.

Note 3.p.115. Iliad. XI. 36-37.

Note 4.p.115. The same. V. 738-740.

Note 5.p.115. Phobos, according to Pausanias, was represented on the coffer of Cypselos with the head of a lion. (V. 19. 4). Welcker believes that he recognizes Phobos and Deimos on two vases, one of which came from Caere and the other from Camirus. (Musee Napoleon. Pl. LIX). The first has the head and paws of a lion with the tail of a horse, the second is figured as a man with the head of a hare. (Archaeol. Zeit. 1881. p. 288).

Note 1.p.118. Pausanias. I. 43. 8.

This mask has not been found in the repertory of Mycenaean art; but except certain monuments where it is found belonging very near the Homeric age, what results from the verses mentioning the monster is, that from the time of Homer, this type was sufficiently known, that when the poet named the Gorgon, he aroused in the minds of his hearers a very distinct image. There is still no mention of the gaping mouth and the protruding

tongue, traits that only appear later to complete the type. What then appeared to characterize it is the eye, fixed and widely open, and in spite of the inevitable imperfection in rendering, the spectator with his lively sensibility sees it gleaming with rage and hate. Thus wishing to depict the expression of the face of Hector, who threw himself into the fight, the poet resorts to a comparison on whose effect he counts. "Hector", he says, "has the eyes of Gorgon".[2] The same conclusion is drawn from the last words of the tale of Ulysses to the Pheacians of his visit to the souls of the dead. "I should willingly", he says, "have continued to converse with the heros; but the people of the dead ran with great clamor, and pale fear seized me; I feared that the august Persephone would send me from Erebus the head of the Gorgon, a shocking monster".[3] That Gorgon's head was then not something indefinite, for the contemporaries of Homer. In speaking before them, they perceived him at once, and the shudders that they experienced ended in confirming the idea, that whoever had allowed the murderous glance of the Gorgon to fall on him was changed into stone. The language held by Ulysses seems to imply that belief; yet one finds it affirmed only in the texts of later date.

Note 2.p.116. Iliad. VIII. 349.

Note 3.p.116. Odyssey. XI. 633-635.

What can best give the idea of the Gorgon as represented on the breastplate is the image, that forms the central motive of the shield of a combatant on a vase of Melos, an image in which is seen the most ancient representation of this type, that has come down to us. (Fig. 13).

On the shield of Agamemnon as on the breastplate of Athena, the mask of the Gorgon appeared in relief, modeled in a plate of metal by the process of repoussee. The assertion of Pausanias would give the idea that it was also carved in stone. By the meaning attached to it, it would have been in its place on the lintel of the gate of a citadel; but one meets in Homer with no allusion to that use of the symbol.

It has been thought that a mention is found of an important work of statuary in the three verses with which opens the description of a dance of young men and girls, that formed one of the representations carved on the shiel of Achilles.

"There also, the illustrious Hephaestos combined a chorus

Like that formerly in the spacious Cnossos,
Dedalus executed for Ariane with the beautiful ringlets".[4]

Note 1.p.117. Iliad. XVIII. 590-592.

Some critics have thought that by the word chorus the poet designated the dancers themselves, that he compared those whose image decorated the shield to a group of figures that Dedalus had sclaptured at Cnossos;[2] One recalls the statuettes of limestone found at Cyprus;[3] there is also cited a passage of Pausanias, that refers to a relief of white marble, some archaic work, that in his time was shown at Cnossos as the very work of Dedalus.[4] These comparisons only rest on an error in translation. We believe that one must here attribute to the word choros the sense given it by the ancient interpreters.[5] It designates not a dancing chorus, but the place where one dances. That is what it nearly always signifies in the epic period, a and which is indicated by the adjectives in composition of which that element enters. When the poet applies these epithets to a city, what does he wish to say thereby, if if not that there are wide and beautiful places for the dance?

Note 2.p.117. One may quote here as having adopted this opinion, Overbeck, Helbig and Robert.

Note 3.p.117. Histoire de l'Art. Vol. III. p. 586, note 2 and Fig. 399.

Note 4.p.117. Pausanias. IX. 40, 2.

Note 5.p.117. Aristonicos attributes this sense to the word choros. He is followed by Ottfried Müller, Welcker, Nitsch and Preller. The reasonsfor adhering to the opinion of Aristonicos have been particularly explained with much force by Eugene Petersen. Kritische Bemerkungen zur ältesten Geschichte der Griechischen Kunst. 1871.

Here is further what appears to remove all doubts. After having aroused the memory of the labor undertaken by Dedalus for Ariane, the poet continues thus:--

"There the youths and the seductive young girls, holding each other by the hand, struck the earth with the feet".[1]

Note 1.p.118. Iliad. XVIII. 593-594.

That adverb "entha" the translators forgot to render. Yet it has its value. Here as in the other representations, the poet commences by defining the theatre on which is played the scene that he describes. Further, this is "a vast and soft fallow",

or "an enclosure covered by an abundant harvest", or "a very beautiful vineyard," and at least once, the transition is made by this same word "entha".[2] It is probably that this place of the dance, whose construction was attributed to Dedalus, was merely a simple concreted area, just as there were in all cities: it must present a special character, that attracted attention. It might have presented an arrangement analogous to that of the labyrinth, that is seen represented on the coins of Cnossos (Fig. 14) and also on a vase with an incised design (Fig. 15).[2] Small and very low walls divide that area into curved paths in which the chorus stands, led by the jumpers that bound at the head of the file: in those curved ways so traced are performed those evolutions of the dancers, that are compared by the poet to the whirling of the potter's wheel. The complex design of the plan would favor the separation into semi-choruses, the formation of those "graceful lines that advanced, one before the other".

Note 2.p.118. Iliad. XVIII. 550.

Note 2.p.118. This conjecture was presented by Otto Benndorf (Ueber das Alter des Trojaspieles, after Reichel, Ueber Homerische Waffen). Benndorf believes that he finds in the dance, subject to the divisions of the plan, the first mention of an exercise, that under the name of the play of Troy was in Italy very much in favor during all antiquity. The dance of the crane, that was celebrated at Delos in memory of the adventure of Theseus and Ariane, with its "perielixeis" and its "anelixeis" must resemble much the dance described by Homer.

It is then necessary to renounce in this passage an allusion to a group that might have existed at Cnossos. If the art of sculpture on stone had been cultivated around the poet, he does not appear to know it. On the contrary, for every work in metal, he lavishes details, which seems to indicate that the goldsmith had made a very marked advance in his time as at the courts of the Mycenaean age. This one would divine from the manner in which the poet speaks of it; "a certain skilful man, instructed in the various arts by Hephaestos and by Pallas Athena extends grace over the head of Ulysses and on his shoulders".[1] One will also note the precision with which Homer in regard to Hephaestos' fabricating the shield of Achilles, describes the procedures of the goldsmith; of all the trades, that was evid-

evidently the one in which technical skill was then carried farthese.

Note 1.p.119. Odyssey. VII. 232; XXIII, 159.

The goldsmith took his motives everywhere. He had taken the Gorgon from the human figure, but the animal with the diversity of its forms offered to his inventive genius more varied resources. Homer describes the brooch of Ulysses used for fastening his mantle on the shoulder.[2] On the metal plate concealing the two tubes that received the pins of the clasp was represented a dog overthrowing a fawn, on whose back he had thrown himself; the trembling victim struggled beneath the pressure of the paws, that had torn its flanks. It i not probable that th this refers to a design engraved with the point; the delicacy of the details would have made the trace of the image invisibl at a distance of a few steps. Now the poet evidences the admiration aroused by the sight of that jewel at the passage of Ulysses; he adds that the dog and the fawn were of gold. This l last indication of the impression felt is best emphasized by the hypothesis of a group composed of figures in very strong relief, executed in raised work in a plate of gold. As for the theme, the primary idea was suggested by one of those oriental monuments, on which one sees deer or stags torn by claws.[1] On the Mycenaean intaglios, the lion devours the same prey.[2] We are nearer the reality in th decoration of the brooch of Ulysses. The creators of that motive had never seen either lions or griffins maddened on their victims; on the contrary, the artist whose work struck Homer reproduced a scene at which his patrons could have been present more than once in hunting.

Note 2.p.119. Odyssey. XIX. 228-231.

Note 1.p.120. Histoire de l'Art. Vol. II. Figs. 280, 447; Vol. III, Fig. 422.

Note 2.p.120. The some. Vol. VI, Pl. XVI, 12; Fig. 428[14].

It was also in repoussee that the figures of animals and men decorated the shoulder-belt of Hercules, whom Ulysses met among the dead. "The shield was of gold; one saw on it all sorts of marvellous works; bears, wild boars, ferocious lions, combats, melees, murders and the slaughter of warriors".[3] Those verses are found in the passage where i found the trace of ideas of far more recent date, than those inspiring the author of the most ancient parts of the Nexyia. It was then not to commit

an anachronism by comparing this shoulder-belt to the diadems made of a thin sheet of gold, that have been collected in several tombs of the Dipylon and of Eleusis, diadems that could date from the 8 th or 7 th centuries.[1] What on sees on those bands is what is indicated by the poet, lives of animals, lions that surprise stags or attack men. Perhaps we shall find on others of those bands battle scenes, like those presented to us as extending around their bodies, by the most ancient painted vases of Chalcis and of Rhodes. One further notes that the the description is far from being as precise here as in regard to the works previously studied. Works of art having become less rare, the rhapsodist no longer regards them with such amazed curiosity as the former epic poet; he contents himself with indicating the appearance in a general way, without emphasizing the details. Those stamped bands are no longer, like the shield of Agamemnon or the brooch of Ulysses, works unique in their kind, expressly created for a hero by the inventive genius of a master goldsmith. The brief charm of the description is then explained in the present case by the use of mechanical procedures, that permit the indefinite multiplication of the copies of the same composition.

Note 3.p.120. Odyssey. XI. 610-612. Helbig. L'epopee. p. 505-506.

Note 4.p.120. Athen. Mitt. 1883. p. 100, 128. Collignon. Histoire de la Sculpture Grecque. Vol. I. Figs. 43, 44.

Among these creations in the arts of metal in which the poet is so strongly interested, there is one, the shield of Achilles, that sets apart the origin attributed to it and the place it occupies in the economy of the poem. The shield is the work of Hephaestos, the preeminent artist, and its convex surface is ornamented by figures that form very varied scenes, which the poet successively describes. He devotes to that description no less than one hundred and thirty one verses, that certainly did not belong to the primitive nucleus of the poem.

Note 1.p.121. Iliad. XVIII. 478-608. One will find a bibliography of the works produced by the study of the restoration of the shield in Buchholz, Homerische Realien. Vol. II. Part 1, p. 385. Note 5. Collignon indicates the most important of those essays. (Histoire de la Sculpture Grecque. Vol. I. p. 70, note 2). We shall content ourselves with adding the indication of

some later works. In some pages in the first part of a work that unfortunately will never be completed, Henri Brunn has gathered the entire substance of his early researches on art in Homer. (Griechische Kunstgeschichte I. Chap. 2. Die Kunst der Homerischen Zeit, and particularly p. 73-85). We cite also an interesting memoir by Solomon Reinach, Le Bouclier d'Achille et les situles celto-illyriennes. (Al. Bertrand and S. Reinach, Les Celtes dans les vallees du Po et du Danube. 1894).p.218-221). Finally, there are ingenious views on this in the Essay of W. Reichel. (Ueber Homerische Waffen. Vienna. 1892. pp. 151+55 vignettes). Kluge claims to distinguish on the buckler two different techniques, each of which was employed only for one portion of the work. (Der Schild der Achilleus und die Mykenische Funde, in Neue Jahrbücher für Philologie und Pädagogik. Vols. 149-150. 1894. Part 2); there is much subtlety.

For a long time, when one sought to take into account the idea, that the poet and his hearers formed of the work of that shield, it was imagined that they represented to themselves figures in relief, executed in repoussee. They should have remembered the function of the shield; it must receive and ward off strokes of arrows, blades of swords. In the contest, when touching each other, the shields struck against each other violently. It is possible that men exposed to such blows some symbol, such as a Gorgon's head, that projected at the centre of the disk and met the eyes. One could give to that part a thickness of metal sufficient not to fear the effects of all those shocks; but it was not the same for the figures, that as actors in the scenes here designed by Hephaestos, were very numerous, could have but small dimensions, and consequently but slight projection. The relief would have been flattened at the first encounter, deformed so as to render the image unrecognizable.

There is then no reason for adhering to the hypothesis of a decoration formed of figures projecting more or less. In spite of its marvellous beauty, the shield of Achilles is not an arm for luxury and parade; the hero will cast it on his shoulders, when he goes to avenge Patroclus. A flat ornamentation was the best according with the purpose of the arm; but this decoration without relief, how is it to be understood, and to what technique is it to be referred? Must one think of figures engraved in line, like those that a point more or less skilful scattered

over the banded urns of Ppeneste and on the situles of Styria and of Carinthia? Doubtlass it is impossible that the graver did not play its part here, serving to trace either the entire outline or to mark certain details in the interiors of the figures; but it gave only the sketch of the form, and the artist adhered to not deprive himself of the resources of the charm of color. He obtained this result by the use of different metals or alloys, bronze, gold, silver, "cassiteros", which was probably an alloy of silver and lead, perhaps mixed with tin; [1] he seems to have had at his disposal certain enamels that gave him blue or black colors. With these elements he could not think of reproducing the natural colors of objects; all that he proposed was to attract attention by the peculiarity of the color of certain personages and certain accessories; thus it is not alone by their high stature that Pallas and Ares are distinguished from the warriors, that the lead to the combat; by the warm tone of the gold of which they are made, those figures of the two divinities are detached in light on a dark ground, that increases their importance.[2] the same effects are more complex in the scene representing a vine or a vintage. Th black of the grapes shows on the gold of the vine; a palisade of silver surrounds the domain, and before it extends a ditch, whose hollow is indicated by a bar of that vitreous paste of dark blue, that the Greeks, who borrowed it from the Phoenicians, term kyanos.[3] Elsewhere is mention of a hedge of cassiteros and of daggers of gold suspended by baldrics of silver.[4]

Note 1.p.122. Berthelot. La Chimie au moyen age. Vol. I. p. 367-368; Introduction a l'etude de la chimie des anciens et du moyen age. p. 250, 251.

Note 2.p.122. Iliad. XVIII. 517.

Note 3.p.122. The same. XVIII. 561-564.

Note 4.p.122. The same. XVIII. Verse 565-598. See 574, 577.

The difficulty was to explain how were harmonized and adjusted such different elements. A very recent discovery has relieved us from the embarrassment; the procedures employed by Hephaestos are the same that we have had occasion to study and define with regard to those Mycenaean daggers, whose curious decoration has been disengaged by M. Koumanoudis from the coating that concealed it from Schliemann.[1] In the bronze plate forming the field of the piece to be decorated, the tool made cavities

of slight depth in which skilful fingers armed with pliers placed bits of metal or glass in very thin sheets, fixed in the ground by the aid of a cementing substance, glue or solder. Thus the artist created a sort of mosaic, a polychrome facing, according to the time and skill devoted to it, and by the interest of the theme, the elegance of the design and the diversity of colors, he could impart more or less amplitude and variety.

Note 1.p.123. Histoire de l'Art. Vol. VI. p. 779-784; pls. 17, 18, 19; Figs. 367, 368; p. 811-812.

Doubtless a decoration of that sort does not form a work of sculpture, in the proper sense of the word. If as on one of the daggers of Mycenae, some of those inlaid bits slightly exceeded the surface of the ground, that projection was very small and almost insensible; one must not seek there the modeling obtained by superposition of planes. The appearance was rather that of painting; but it is due to the hammer, the point of the chisel employed by the workman to execute this work. The goldsmith, whether he projects his figures from the ground or inlays them flush with it, remains a sculptor.

If one is able today to define the technique from which was derived all that decoration, then is no longer any doubt in the matter of knowing by what principle the scenes traced by Hephaestus were distributed over the surface of the shield. The heros of Homer appear to have used at the same time the narrow oval shield, that covered the entire height of the body, and the round shield, that while leaving the legs exposed, mor efficiently protected the bust; but the circular form seems to have been more commonly employed, as indicated by the epithet "well rounded", frequently applied to the shield, and the frequent use of the word "circle", where the poet describes the shields of the combatants, and shows how they make use of th[illegible]. The decisive reason that further requires here the preference of the last type, is that it lends itself bette than any other to the grouping of the scenes, to the necessities of a symmetrical arrangement. All archaeologists, that have attempted to restore the shield of Achilles, give it the form of a disk.

Note 2.p.123. Helbig. L'epopee homerique. Chap. 23.

The author of one of the best studied of these restorations, while adopting the disk type, has arranged it to be divided by two deep indentations, that give it the appearance of certain

represented on the potteries or golden plates of the age of the Dipylon, and what was later called to Boetian shield. (Fig. 16).[1] This method appears to him to have the advantage, that the double notch at least separates into parts the portion of the shield most distant from the centre; he believes that thus is obtained a form with divisions better marked. Perhaps it is so; but what makes this conjecture improbable is an epithet, that continually recurs in the two poems. The shield is termed "equal in all senses", i.e., every equal to itself; that epithet seems to exclude all idea of a recessed outline. Further, assume these two notches opened in the edges of a disk; they would have allowed arrows to pass, and the poet, in one of those episodes of the combat where with so much precision, would scarcely have failed to allude to some accident of that kind.

Note 1.p.128. A. S. Murray. History of Greek Sculpture. Vol. I. Chap. 3. This would also be the opinion of Reichel.

One can neither admit that the different scenes were scattered at random on the field of the shield, nor that the poet in his description proceeds by chance; but among all the motives enumerated, there is only one for which is clearly indicated the place it occupies on the disk. "Hephaestus also placed the river Ocean, that irresistible force, near the border that limits the shield of excellent work".[2] One divines from that trait the order that Homer followed; if he stops when he has reached the circumstance, that is because he started from the centre. The theme that he mentions first further lends itself better than any other to supply a central motive, as it is termed in the style of the atelier.[1] Where are placed, if not on watch in a sort of medallion, the earth, sun, moon and stars? There was the most natural place to group those celestial bodies, that man had adored before diverting himself to gods made in his own image. Those stars are seen thus represented on the oriental cylinders [2] and on the bezel of a Mycenaean ring;[3] but the form of the seal not being the same as that of the shield, the engraver in the intaglios has combined the sun and planets near the top of the field. The arrangement is different, but the principle is the same. On monuments that resemble more the shield, on metal caps with incised and repoussee designs, that were made in Assyria and Phoenicia has not yet been found so

motive in question within the in ernal circle; but one can recall in this respect two cups from Nimroud, where the principal motive of the decoration causes one to think of that to which Hephaestus had assigned the place of honor.[4] At the circumference, there are on one various personages, that with varied attitudes have entirely Egyptian countenances, and on the other is a series of passing animals; but in one part of another, what fills the greatest part of the field is the earth with its mountains and valleys, peopled by men and wild beasts. The idea is not entirely that of the Greek poet. That cavalier perspective also arranges the idea of indefinite space and of the life developed there, excited and maintained by the lights of day a and night, inexhaustible sources of heat and light.

Note 2.p.124. Iliad. XVIII. 607-608.

Note 1.p.125. Iliad. XVIII. 483-489.

Note 2.p.125. Histoire de l'Art. Vol. II. Figs. 330, 342, 350; Vol. III. 426, 446, 457, 474; Vol. V. 504, 505.

Note 3.p.125. The same. Vol. VI. Fig. 425.

Note 4.p.125. Vol. II. Figs. 406, 408.

Between the middle portion of the circle and the narrow band of the sea that borders its circumference remains a wide field, where had found places the varied scenes, that the poet was p pleased to trace. Each of those scenes must have its enclosure; otherwise the observer would lose himself in these swarming figures, whose role and meaning he could scarcely seize; even the free intervals or blanks reserved between the different groups, would not have sufficed him to quickly orientate himself. There were required clearly marked divisions, separations whose principle was given by even the form of the surface to decorate. This principle is that of dividing this surface into a certain number of annular bands, each of which is limited by a projecting edging, and could in its turn be divided in the same manner into two or several compartments by rays toward the centre of the circumference. The rigorous symmetry of those concentric curves pleases the eye. Further, this division into parallel b bands,combined with the division into sectors, has the advantage of supplying the artist with enclosures already prepared for his scenes; by the arrangements it permits, it lends itself to emphasize the correspondences or the contrasts presented to the mind by certain chosen themes. This method was so clearly

indicated, that without previous agreement it was adopted among different peoples by the workmen, to whom was entrusted the task of filling the fields of elliptical form. That is proved in Egypt by a tablet of glazed clay anda golden breastplate,[1] and in Assyria by shields represented on the monuments, several examples of which shields have been found, and then also by the metal caps already seen.[2] This arrangement is again found in Phoenicia on the same cups of bronze or of gilded silver;[3] one finds it on the vases and jewels of the Mycenaean age,[4] as on the phaleras and votive shielsd, that have been collected from the very ancient tombs of Greece and Italy.(Fig.17). Finally, during the archaic period of Greek art, the ceramic painter employs no other method for tracing the principal lines of his ornamentation, when that must be applied to the bottom of a cup or plate, That expedient is first presented to t the mind, and the artist only ceases very late to resort to it, when he has attained to that grand taste, that seeks effect in even sobriety of ornament, in the desired simplicity of one or two figures detached in light on the brilliant black ground of the glazing.

Note 1.p.127. Histoire de l'Art. Vol. I. Figs. 580, 589.

Note 2.p.127. The same. Vol. II. Figs. 190, 215, 398, 399, 405, etc.

Note 3.p.127. The same. Vol. III. Figs. 482, 543, 544, 548-554.

Note 4.p.127. The same. Vol. VI. Figs. 468, 469, 529.

The images of the central group, of the earth and the stars, perhaps had a certain relief, that enhanced it importance. In any case, one cannot regard them otherwise than as enclosed by a projecting fillet; that formed at the same time the internal outline of that zone adjoining this medallion. As for the number of the bands, when one assumes an arrangement taking into account the correspondences and contrasts indicated by the poet, it seems agreed to fix these at three, without counting t the ocean, that forms the border. With this border and the central medallion, we reach the number of five divisions.[5]

Note 5.127. One has sometimes sought an allusion to these d divisions in this verse:-- (Greek), XVIII. 481.

Now "ptyches" does not signify here circles but layers; it i is inthe sense of thickness, that there are five ptyches, as demonstrated by the story of the combat between Eneas and Ach-

Achilles, that covers the divine shield. The lance of the Trojan only pierces the two first layers (Greek); it is stopped b by the third. There were two layers of bronze, two of cassiteros and one of gold. (Iliad. XX. 264-273).

The representation of the city in peaceand that of the city in war filled the first band; the two descriptions have nearly the same extent. Thus one would divide this band in half between the two scenes, or rather between the two series of scenes, for each one of these themes is divided into several detached scenes, that are as many different expressions of one or the other of the two ideas here concerned, the idea of the blessings of peace and that of the evils of war. In the illustration of the second of these subjects are distinguished three successive moments or scenes. An attacking enemy is divided into two groups, surrounds and menaces the city, on the walls of which are the womenchildren and old men. A troop of warriors are led to the combat by Pallas and Ares and make a sortie. Finally an ambuscade is formed near the river, the desperate struggle that results for the possession of the herds between the besiegers and the besieged. One is inclined to seek in the other half of the band the same triple division, and finds it there, if he admits that one of the scenes is only expressed by one word, "festivals".[1] Then comes the nuptial procession, passing along the streets of the city, by the light of torchesand the noise of the hymeneal songs; then the judicial debate occurring in presence of the multitude on the market place. The poet is not compelled in that episode to depict everything wit the same detail; according as the mention of a certain subject arousesin his mind more or fewer images, he extends or reduces the description. Weddings amuse him; he adheres to giving a view of them and to recalling the noise, while for the repast, that does not offer such a varied spectacle, he refers it to the memories of his auditors.

Note 1.p.128. Verse 490. (Greek).

Without transition the poet passes to another series of scenes, where are represented the labors of the fields in the order of the seasons.[2] That is not divided like the preceding into two groups contrasted to each other. There is not a matter for antithesis; but by the idea from which they proceed, all these scenes have an intimate connection; they form an entire-

entirety, which is like a rapid sketch of a poem analogous to the Labors and Days of Hesiod and to the Georgics of Virgil. The series of those scenes fill the second zone. The poet enumerates five of them, one of which could easily be cut into two scenes, if in a graphical representation he desired to reach the equal number of six for any reason of symmetry.

Note 2.p.128. Verses 540-589.

Labors are resumed in the spring; several plows turn over t the soil of a vast fallow. Summer is the harvest, with young men whose sickles lay the heads on the earth, the children that gather them and the binders that tie the sheaves. In a few words the poet seems to indicate a third scene that however oc occupies a separate compartment, while connected with the former. "At the side the heralds prepare an abundant repast beneath an oak; they have sacrificed a great ox that they bring; t the women aid them by sprinkling the flesh with white meal". A After the harvest is the repast, that assembles all the laborers that have finally reached the end of their hard labor. For the autumn is the vintage. With the harmony of his lute and h his sweet songs, the musician enlivens the workers and regulates the cadence of their steps in the path, where they carry t the baskets loaded with grapes. No allusion to winter, the time when are interrupted the labors on the land; but after the life of the cultivators, the poet depicts the pastoral life, of which he represents two episodes. Here "on the banks of the sounding river bordered by frail reeds" is a herd of oxen attacked by two lions, that the dogs and herdsmen dare not drive away. There are large and white sheep that feed in a vast meadow, near which rise the huts of the shepherds with the stables and parks. In that band as in the other, the artist has sought an effect of contrast; near a scene of violence has he placed another, where all breathes calm and safety.

The study of the text of the very clearly defined character of nearly all the scenes described there, gives reason to believe that it is expedient to represent them as separated from each other by fillets, perhaps projecting less than those separating the bands, yet still sufficiently marked to form an enclosure. Thus one has a division in sectors, that combines with the division in annular bands.

In the diagram by which we have indicated the arrangement of

the scenes that decorate the shield, we stop the sector lines at the outer lines of the second band.(Fig. 13). This is the only theme remaining at disposal for filling the third zone, t the last mentioned by the poet, presenting a character of unity that we have found neither in the rpresentation of the two cities, not in that of rural life. This theme is the image of a dancing chorus composed of youths and young girls.[1] Doubtless all the persons here do not have the same attitudes. "Sometimes the entire chorus, as light as expert, turns rapidly round like the wheel of the potter, when it finds whether it can aid the skill of its hands. Sometimes the dancers separate and form g graceful lines, that advance one before the other. The multitude admires them and delights in these games. A divine poet with the accompaniment of his lyre animates them by his songs. Two agile leapers, when he begins, respond to his voice and whirl in the midst of the chorus". All that however is only t the successive moments, the varied figures of the same dance. The field is then not divided here into several compartments. By the continuity of an uninterrupted action and by the rhythm of the poses regulated by the musical cadence, this troop of dancing youths and girls has a character differing from that of the scenes filling the two inner bands; it is like a skilfully managed transition from those complex scenes of the last t band, the ocean, that around all that life extends the uniformity of its peaceful and tranquil mass.

We have studied the work of Hephaestus, as if we admitted that it had an actual existence; all the scenes described, like them have been distributed in our five bands. For it to have been thus, the poet must have seen, either with the eyes of the body or at least the eyes of the spirit, his figures distributed within an enclosure like that traced by our compasses. Otherwise, the correspondence between the description of Homer and our diagram would have been obtained only at the cost of combinations more or less forced. It them seems certain that the attention of the poet was fixed on shields or scenes of the kind that he enumerates, which were grouped thus, and the monuments confirm this hypothesis. Some exist that present that arrangement, and which appear to date back to an age very near that, in which was composed this episode. We have already cited as a type of the division in concentric zones a bronze disk (Fig.).

The arrangement is the same, but with a more developed ornamentation, in one of the votive shields comprised among the objects deposited in the sacred cave of Ida in Crete, articles attributed to the end of the [illegible] th or the beginning of the 7 th century. (Figs. 19, 20).

One has started from that to affirm that the author in that entire passage has only described a work of exceptional importance and beauty, a rare waif from the shipwreck of Mycenaean civilization. Entirely covered by figures that excite curiosity, all gleaming with the splendor of the precious metals and rich enamel, this shield would have been preserved in some sanctuary or in the treasury of a prince; the poet would make himself the interpreter of the admiration aroused by that marvel of an art very superior to that of the new generations, weak heir of a world, where all was grander and more beautiful. The conjecture at first sight seems specious; however I believe that I can see more than one reason to divert from it.

There is reason to think that we know today at least all the chief types created by Mycenaean art. Now if the processes employed by Hephaestos are indeed those practised by Mycenaean goldsmiths, on the other hand nothing has been found, either in the tombs of the funerary enclosure or in other sepulchres of the same period, that in extent and development of the composition are comparable to the shield of Achilles. The shields to be seen figured on the Mycenaean intaglios can only have been wooden boards, on which were fixed on the edges and at the centre, bosses and plates of metal. A lion's head is awkwardly sketched in some lines on a plate of gold, and is the sole remnant that appears to have belonged to an object of this kind. It has been believed that there is recognized the handle attached at the middle of the arm.[1] The goldsmith seems to have utilized the figure of a man only to ornament objects of small dimensions, such as cups of gold, silver or bronze and blades of daggers. On all objects presenting a sufficiently large surface, on diadems, on long strips suspended from vestments, a pectoral of gold more than [illegible] ins. wide, there is no decoration other than linear ornament, bosses, spirals and rosettes.

Note 1.p.132. Histoire de l'Art. Vol. VI. p. [illegible].

Note 2.p.132. The same. Vol. VI. Figs. [illegible].

A final observation also lessens the [illegible] of probability,

one might be tempted to attribute to that hypothesis. In none of the deposits of ancient objects, whose formation dates back to the time of Homer or at least to an epoch very near it, nor in the cave on Ida or in the necropolis of the Dipylon, has a anything been found, that can pass as a work of Mycenaean manufacture. The pottery, jewels and metal vases collected there bear the impress of the styles that succeeded the Mycenaean style, of the geometrical and the so-called oriental style. If in the states formed after the Dorian invasion, the rich and the nobles still had in their hands the sumptuous products of the artisans of Orchomenos, Tiryns and Mycenae, they would have consecrated them to the gods or have taken them with them into the tomb, instead of applying for their offerings and funerary equipment to workmen, that could not rival even afar the earlier masters; we should find those legacies from prehistoric Greece mixed with objects of very much later date. Now it is not so, and one further explains that during the two or three centuries which followed the descent of the northern tribes into Greece, the monuments of the earlier civilization were destroyed in great numbers, and that those alone remained which were deeply buried in the earth. Between the fall of the ancient order and the establishment of the new one are divined the encounters of the peoples, murderous sieges and long blockades, pillaged cities, exile imposed on the vanquished, rapid flights with little baggage. Of all objects exposed to these chances, those that also risked being most quickly destroyed were those, where gold and silver furnished the material; these were vessels, ornaments and show arms. It would be singular if such a work as the shield of Achilles had passed without accident through two or three centuries of troubles and violence.

So then assuming that a work like that of the decoration of the shield were not above the abilities of the Mycenaean goldsmith, an object of such great value to all appearance, would have entirely disappeared long before the time when one of the later poets, who collaborated in the Iliad, inserted therein the episode that occupies us.

On the other hand, we cannot admit that in the time of Homer were artists capable of executing work like that here attributed to Hephaestos. If one attempts to restore the composition, he finds a considerable number of figures; there would be nearly

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as many as in the works belonging to a much later period of t the development of the art, in the coffer of Kypselos, for example, or on the vase known under the name of the François vase. The subjects engraved on the shield present scarcely less variety than those decorating the creations of the sculpture of the 6 th century, and the scenes described by the poet would have been unintelligible, if the signification had not been clearly indicated by the correctness and variety f the movements. Was anyone then capable of attaining this result? It is allowable to doubt it. The vases of the Dipylon are the sole monuments t that one has some reason to regard as contemporaries of the last singers, that aided in the completion of the epic period; now with means of expression so moderate as those at the disposal of the ceramists, how could the goldsmith have clearly defined so many personages by their attitudes and their gestures? The goldsmith was certainly more skilful than the painter of vases; yet in the few jewels that appear to date from the Homeric age, there is nothing that permits one to attribute to that artist the mastery required by the execution of a work as complex as that described by the poet.

Me do not yield; they make a distinction by which they claim to solve the difficulty. "This would not exist, if we could attain tc a more accurate account of the appearance of the images, that furnished his theme to the epic singer. We err in representing them to ourselves as always similar to those designed today by the artist, if he were given the Homeric description as a programme; at most we should restrict ourselves to seeking the elements of a restoration of the shield only in the reliefs and the vases of the 7 th and 6 th centuries. There is a manifest error. Those archaic monuments, in spite of their inaccuracies, comprise a multitude of personages and a precision of detail, that were required from the primitive artist. When he had to translate his ide into form, he indicated his thought rather than he expressed it. His figures scarcely had more value than signs, they were rather suggestive than representative. A large disk with a head and legs was a soldier; two or three soldiers were an army; two or three dancers were an entire chorus

Note 1.p.134. Brunn. Griechische Kunstgeschichte. p. 84.

There is truth in that observation. Yet we shall make a remark of importance. If certain very simple themes lend themselves

to such a summary mode of representation, there are others among those enumerated here by the poet, that adapt themselves to it less readily. For two bands of warriors that menace the city is no difficulty; but so that the observer may seize at once the sense of the image, there are required more ways to render such special attitudes, as those of the different groups of workers that labor in the harvest, of women that strew with meal the flesh of the sacrificed bull, or of the leapers whose bold bounds contrast with the slow and cadenced steps of the files of dancers. If like the painter of the Dipylon, the goldsmith bends the human form into the dryness of geometrical drawing and thus deprives it of all life, how by that means could he clearly indicate the technical gestures of the harvesters, of the preparers of the meats and of dancers?

By certain traits it has been thought to divine, that the poet was here the interpreter of the artist, whose work he had under his eyes, limiting himself to explaining the sense of the scenes that he saw figured on the disk.[1] He does not seem to have always properly seized that sense; one can find the trace of the embarrasment, that he experienced before certain groups and errors that he committed in seeking to propose a plausible interpretation of them.[2] All that seems more ingenious than convincing: the reading of the text leaves us with a quite contrary impression, that of a poet entirely occupied in describing the scenes invented by him, and troubles himself little to know how the artist undertakes to represent by forms, what he easily expresses by words. Thus when it concerns a court debate on the agora or the preparations for a siege, the poet hears the words pronounced by the authors of the scene; he exhibits to us their ideas and projects. It is said that it is necessary for him to find a signification for the images engraved on the shield. Again pass to the lawsuit discussed before the old men; rigorously the goldsmith could have represented this theme so as to suggest to the observer some explanations of this kind; but how and by what artifice he could have shown by the arrangement of the groups alone, that among the enemies menacing the besieged city, there were some desiring to sack it, while others would be satisfied by imposing on the vanquished a division of their goods and lands? It seems to us, that what he felt here is not effort of a poet that endeavors to seize the intentions of the

artist, but rather the free course of an inventive mind, that not having to count on the conditions imposed by the material on every translation of the idea into relief, ordains at his pleasure the scenes conceived by his vivid imagination, reads the souls of the personages created by him, and enters into their feelings. **The poet labors with his head**; but what he demands from the concrete and actual works of the arts of metal is, to lend him the ground on which he projects the actors in those different scenes, which serve him for representing certain aspects of contemporary life.

Note 1.p.135. Brunn. Grëechische Kunstgeschichte. p. 73-74, 76. This is also the opinion of Reichel. (Ueber Homerische Waffen. p. 46.

Note 2.p.135. This is what Reichel seeks to show in regard to the scene of the tribunal and to the siege of the city; thus in the last, the poe erred in not taking for gods the chiefs represented at the head of the troop, because they were larger than the other personages and had more beautiful arms.

Being given the point of view at which we are placed, one will not be astonished that we have not attempted to offer a figured representation of that shield; one does not restore only what has existed. Besides, even when we have admitted that the poet described here what he had seen, we should not think that he had reason to seek to reestablish the composition that decorated the field of the shield. This mode of omission is easy for us to justify. Aside from perhaps some finds, there is possessed not a single work of toreutics (so the Greeks termed the art of working metal wit the chisel and graver), that one can in a measure attribute to the age, that saw produced the last flowers of the epic period. The sole monuments with figures to which can be assigned that date are the oldest clay vases of the Dipylon, and nothing authorizes us to affirm that the fabrication was exactly similar in the works of the toreutian and in these of the ceramic painter. That style is unknown; we do not have the elements that define it. It has been thought to find a means of supplying the absence of the indispensable data; men have taken on all sides in the art of several peoples, scenes analogous to those that the poet describes, and all those scenes from various sources are joined in a framework similar to that designed by us.[1] Those borrowings were made indif-

indifferently from Egyptian paintings and Assyrian reliefs, P Phoenician cups of metal, vases from Corinth and from Chalais; but what can be the value of the result obtained by that method? The sole interest that it presents is to show that the poet was in them unfamiliar to oriental art, or at least to ancient Grecian art; but the entirety thus formed necessarily presents incongruites; there is not that unity that could produce the illusion of truth divined and recovered.

Note 1.p.138. This is what Murray has done in the plate accompanying Chap. 3 of his History of Greek Sculpture.

Every attempt of this kind then appears condemned in advance to assured defeat. On the contrary, if one undertakes to reconstitute this composition by adopting for the execution of all the figures one and the same style, he must necessarily commit an anachronism. To draw them similar to those that the brush has thrown upon the vases of the Dipylon would not be thought; that mode of representation would appear too barbarous. One One would then seek his model either in the work of the Mycenaean goldsmith or that of the painter of Corinthian vases; but when Hephaestos fashioned the marvellous arm, Mycenaean art had long since terminated its evolution, and the potters of Corinth had not yet kindled their ovens. The choice tha one would make between the two styles then remained entirely arbitrary. It is better to renounce attempting the undertaking, yet without forgetting that the men addressed by the epic singer had known nothing, either by choice of subjects or by arrangement of the scenes, that would resemble the shield of Achilles, all this ornamentation would have would have failed to interest them. They would not have admitted the probability; what he desired to show them, they would have seen. The creation of the poet must then be regarded as a work of art, an ideal work that had its prototypes in reality. All the difference is that the poet did not have to restrict himself within the narrow limits, that practical requirements imposed on the artisan; thanks to that indeterminate extent of the field, he could give to that imaginary decoration a complication that we shall not find in any of the best works of contemporary industry, if a fortunate excavation should restore them to us.

Like so many works of art, the shield presents two characteristics, one of which as evidence of its high antiquity distin-

distinguishes it from the works of classical art, while by the other it precedes them and already applies the principle. That diversity and that resemblance would be seized with difficulty, if you compare the shield of Achilles to the coffer of Kypselos and the Francois vase; we shall expressly choose the terms of comparison in the domain of that archaic art, that by its date is nearer the Homeric art than any other.

The comparison will first bear on the nature of the subjects. Now in the two monuments that we have chosen as representatives of the art of the 7 th and 6 th centuries, the themes treated by the chiseler and by the ceramic painter are taken from t the Iliad, the Odyssey and the so-called cyclic poems.

For us the action passes in this world of myth where the Greek imagination, after its education in the school of the epic period, has always felt itself more at ease than in the real world. From that time myth has interested it more than history; it has appeared more true, true with superior verity, less subject to doubt and revision than actual history; thus during a very long time until the hour of the last transformations of taste, it has only been by exception that the sculptor and the painter have sometimes sought their subjects and their personages elsewhere than in the repertory prepared for them by poetry. It is entirely otherwise with the description of the shield; there with some traits that could disappear almost without being perceived, one scarcely divines that Greece had thenceforth a mythology, that known by Homer. Thus Athena and Ares direct the sortie of the besieged.[1] Also in the conflict, with Discord and Tumult, the keres often named in the Iliad, drag the dead by the feet on the field of battle.[2] There are no other allusions at all to the supernatural in the midst of which is completed the action of the poem. Hephaestos comprised in his programme no scene, that might have as a stage either Olympus or Hades; he does not leave the earth, and the authors of the dramas played there are not the gods and heros, whose adventures and interventions in human affairs supply such rich material to the art of the later centuries. Hephaestos does what Helen did, when on her wide peplos she embroidered the image "of the combats that for love of her were imposed upon the Trojans, breakers of horses, and the Achaians with tunics of bronze."[3] What he represents is what he sees, certain forms and

certain appearances of contemporary life. Mycenaean art had a some habits; it worked on the same lines. The art from which was derived the shield of Achilles did not suffer the influence of the epic period; it did not place on the stage the personages that it had created. It had then not yet entered into the path into which the genius of form of Greece did not delay entering, when the Homeric poems and those connected with them had become the common patrimony and like the Bible to all the Grecian tribes. By this trait, this art is then connected with the traditions of the past, a past that men have sometimes refused to place to the account of the Greek people, and to regard as the preface of its history.

Note 1.p.138. Iliad. XVIII. 516-519.

Note 2.p.138. Iliad. XVIII. 535-540.

Note 3.p.138. Iliad. III. 126-128.

On the other hand in the arrangement, the shield is truly a Grecian work, nearly related to the works of the following period. In the arrangement of the decoration invented by him, the poet is inspired by the principle that classical are never fails to apply, whatever the procedures and the material that it employs in the execution of its works. This principle is that there is a relation to be sought between the theme chosen by the artist and the field, where that theme is developed, between the different parts of the theme and the divisions of the field, these concurring by their dimensions and their relative situation to emphasize the main idea, and to illustrate all its sides. This result is obtained by very simple means. Each of the bands into which the disk is divided has its special purpose. The same zone combines by the band and a common idea scenes, that are the varied expression of the same thought. Here within these enclosures the scenes form antithetic series opposed in pairs; such is the case for those representing the city in war opposite the city in peace. Here they are pendants to each other without presenting possible contrasts; thus are grouped those representing the country labors. Elsewhere the same scenes, the image of a dancing chorus continues and extends the entire length of the annular band. The happy balancing of those motives, that correspond in the sectors of the same band, give the impression of a work created by a mind already very capable of reflection. There is here a science of compos-

composition, a vivid feeling of order and of its virtues that we have not found, at least carried to the same degree, either in the art of the peoples of the Orient or in Mycenaean art. The decoration whose creation is attributed to Hephaestor only existed in the imagination of the poet; still in a certain sense, this is the first and most ancient monument of Greek sculpture.

The power of combination that strikes us here is a novelty is not revealed alone by this ingenious distribution of the motives. One also divines the effects in the first conception of the th theme. In spite of the number and diversity of the scenes, that has its unity; the secondary ideas that there express all those images are connected in an entirely logical order. It does not seem to us that there may be an excess of subtility in the analysis of the economy of the plan, presented by a learned historian of art. We cannot do better than to translate this page.

"The stage on which are produced the different manifestations of the activity of men is the earth, which is represented at th centre of the shield, covered by the vault of the heavens, in which the stars accomplish their eternal revolutions. The earth is supposed to extend to the ocean, that forms its limit on all sides. The contest breaks forth on its surface. There are disputed the ground and the wealth; until property is finally guaranteed by constitution of the family founded on marriage and by the establishment of regular justice. Then only can one undertake and properly carry on the works of peace, following the order of the seasons; but even the success of those labors is not the supreme purpose of life; they find their natural end and recompense in the celbration of joyous festivals.[1]

Note 1.p.140. H. Brunn. Griechische Kunstgeschichte. I.p.75.

Doubtless not under that abstract form was the mother idea presented for the composition to the mind of the poet; but it may well have been at bottom what we have just developed. Otherwise and without constraining it, we could not reduce it to these terms. In the sketch traced by Homer, one already feels the effort of an idea that dominates his subject, that he perceives all its details and connects them to the entirety, and that creative and ordina ing reason, that presided at the birth of the works of sculpture to which will later be devoted our

attention; but there will still be necessary for the artist one or two centuries of patient labor, for him to learn to translate into the language of form what the poet henceforth so clearly conceives and expresses with such masterly ease.

It has been desired to institute a comparison between the scenes figured on the shield and the Assyrian reliefs.[2] We do not see on what it can be based. Would it be on the fabrication? But the style of the sculpture contemporaneous with Homer is not known to us by a single specimen. Would it be on the general arrangement of the composition? But by virtue of the adoption of the system of concentric zones, the decoration of the shield has a unity lacking in the Assyrian relief, which is capable of extending indefinitely in length without knowing any limits, other than those of the wall on which it develops beyond view. Finally, would it be on the spirit itself of the work, on the feeling by which it should be inspired? But there again we perceive only differences and even contrasts. Truly in Assyria, in all scenes represented there is only one actor that counts, the king. The secondary personages around him, who appear by hundreds under the skilful chisel of the sculptor have no reason for existence other than to emphasize best the grandeur and power of the sovereign. All that imagery is only the glorification of the pride and caprice of a single man. There, if ever, is a monarchical art. Quite otherwise is the statement of the decoration of the shield. In that the entire description only once is mentioned the king, and that king has nothing of the majestic and terreble king of the sculpture of Nineveh, b before whom are piled a heap of severed heads, and who places his foot on the neck of rebels. This is a great rural proprietor, who "stands on his furrows, leans on his sceptre, and silently looks on the ears falling under the sickle, rejoicing in his heart."[1] The presence of this good-natured king in one alone of these scenes, is a detail without importance, that passes almost unperceived. Here the actor always on the stage is already the demos, i.e., the people, here the people of the city, that all throw themselves before the enemy to defend their menaced hearths, and that on their agora are present at the judicial debates presided over by the old men, natural magistrates of the growing state; there the people of the village where the men, women and children concur in the common labor. The

poet sings for all. All take their part in these festivals and these dances, where they seek recreation and forgetfulness of the dangers of war from discussions of interests and the rude labor of the fields. It is already the Greek life with equality of duties and of rights, which is established between all that forms a part of the same urban group, with the large place reserved for civic fe tivals, for enjoyments of feeling and imagination, for all that can rest and refresh the soul, restore its elasticity, that always risks being destroyed by the weight of the daily toil. This art is ~~ame addressed~~ to all children of the city; by the spirit animating it is it truly republican.

Note 2.p.140. Brunn. Griechische Kunstgesch. p. 77-81.

Note 1.p.141. Iliad. XVIII. 586-587.

One is astonished not to find among the scenes figured on the shield scenes, that represent religious pomp and maritime scenes; but why assume that the poet desired in that episode to present a complete image of contemporaneous life? Certain aspects of that life struck him, and he has described them; if he has neglected others, this is because they were not at the moment presented to his mind, or that they did not enter the scheme that he had traced. In a certain measure, one can divine the reason of those omissions. Religious ceremonies are celebrated before the altar situated in the court of the house or on a high place; they did not yet have the importance and splendor, that they will assume when are erected those temples, which will soon be erected. It is the same for the absence of ships. The Greeks do not live on the water like the borderes of the Nile and Euphrates; their civilization is not closely connected with boating; their strong cities were at some distance from the sea, and strangers are charged with exporting the products of their soil and industry. The Trojans have no fleet; the Greeks in the Iliad possess only transport vessels. The great development of the Ionian marine is later than the time when the epic period chose its themes and decided on contours.

We shall not occupy ourselves here with the shield of Hercules. It is tot that this description does not lend itself to interesting observations, that it would not be profitable to compare it to that of the shield of Achilles, which suggested its idea;[1] but the epic fragment where it is developed in nearly two hundred verses does not precede th 7 th century. What

permits the indication of that date is especially the character of the decoration. That still comprises scenes takes from real life; but one also finds there themes drawn from mythology. Thus in one zone is the combat of the Centaurs and Lapiths, at which Athena and Ares are present, jus as Apollo witne sees it on one of the pediments of Olympia. Elsewhere Perseus pursues the Gorgon, the chorus of immortals bed by Apollo and the muses, that in which the Fates are each named. Nothing better marks the difference in time. The description to which is attached t the name of Hesod bears the impression of the age when the epic poet had completed his tour of Greece, and began to impose on the imagination customs entirely novel. This tends to no longer see life except through myths, the feelings and ideas advanced in it at the sight of life, it henceforth translates into the language of myth.

Note 1. 142. Brunn. Griech. Kunstgesch. p. 85-88. Studniczo has devoted to thi shield a study in which are found all its ordinary qualities. (Ueber der Schild des Herokles. 1888. In Serto Portebicono).

To obtain an idea of the art of the sculptor in the 9 th and 8 th centuries, we have only been able to use Homer's descriptions. Yet the tomb of the Dipylon furnished in 1891 monuments, which there is reason to regard as contemporaneous with the completion of the two great epics. These are figurines of ivory, that were found in an interment, which the style of the v vases enclosed scarcely allows one to place later than the first olympiads.[1] There are five of them.

Note 1.p.143. We have collected all that concerns that find in an Article in Bulletin de correspondence hellenique. 1895. p. 273-295. We thank M. Homolle for the courtesy with which he has lent us the cuts of the Bulletin.

Of two of them remains here only the upper part of the body as far as the bottom of the thighs (Fig. 21), and there are the legs below the knees. (Fig. 22). Most are so broken that nearly all details have disappeared; but even on those images that have suffered most, one still sees the pose of the entirety of the form sufficiently to recognize that the five little figures are at a different scale and merely replicas of the same type. We shall define this type by that of these statuettes, both largest and best preserved of all. (Plate III and Fig. 23).

The statuette is 9.45 ins. high and is mounted on an ivory tablet, being fixed to it by iron tenons. The same tenons also serve to attach to the shoulders the arms in separate pieces; by the model of the chest it is recognized that the image is that of a woman; the projection of its bosom is particularly apparent in the profile view. No trace of clothing; nudity appears complete, and yet here and in another of those images (Fig. 24) is a line tightly drawn above the haunches, which gives the idea of a narrow ribbon. Is that a girdle, or indeed is it necessary to see there only a wrinkle in the flesh, merely a conventional indication that concurs with the exaggerated reduction presented at that point by the figure, to mark the border that separates the thorax from the abdomen? I incline to the second hypothesis; tendencies of that kind are found in the most ancient Greek sculptors.

The figure is in the attitude of absolute immobility. It has the legs in contact, arms hanging with hands extended and placed against the thighs. The hair is concealed in front by a high cap (polos) decorated by a fret, and falls very low behind, to between the shoulders. It is divided into several tresses by vertical lines in each; the twisting of the locks composing it is indicated by oblique hatchings.

There is some stiffness in the manner in which the cap is p placed on the brow, in the nearly right angle made with the neck by the shoulder, in the movement of the arms and legs. T The body is restrained too much above the haunches and the abdomen is lank. Yet the proportions do not lack correctness; the sculptor has well marked behind that projection of the pelvis, which distinguishes the woman from the man. One even feels in the slender stature given to the figure a certain instinct of elegance.

What is less successful is the head; it is too large for the body. The artist felt a real embarrassment, when it was necessary for him to render the face with the complexity of its details. The ears are placed too high, the eyes are too large; the nose is too heavy, the lips are too thick; the chin is flat. There is less inexperience in the manner in which are treated the extremities. The hands are only roughed out, and if the f feet are broken off, it is seen by another of these statuettes, that the artist made no effort to model them with precision.

The other images reproduce without notable variations the same motive. One of them is almost intact. (Fig. 25). We have described a reduced copy of this; the cap is only decorated by vertical lines' the graver was found too large to trace the turns of the fret. As for height, two other images are a mean between that entire figurine and the large statuette. On one only th feet are lacking (Fig. 24); but the entire face has disappeared. The othe is broken a little above the knees.(Fig. 21). The head was detached and was carelessly replaced; it was believed at the first moment, that there was seen the trace of a pointed beard, whose mass would have been indicated, as in certain Cypriote statues' but on examining it more closely, it was recognized that this was a mere illusion, explained by the form of the break.

Besides pottery and the statuettes, there were collected in that excavation quite numerous pieces of bone inlays, that must have served to ornament boxes or other objects of the same sort. These are disks ornamented by a star, lozenges pierced by a hole, a rudely imitated dolphin. finally, one also obtained from that excavation three little couched lions lions lying down, of Egyptian faience covered by blue enamel (Fig. 26), beneath the plinth on which they rest are distinguished hieroglyphic characters, some of which can be deciphered again. (Fig. 27). There is read the name of Ahmes, which was used in all times in Egypt, but which seems to have become in more frequent use about the end of the New Empire under the Saite princes.

Note 1.p.145. On other finds of objects, such as scarabeuses, covered by the same enamel, made in the tombs of this epoch, see Eph. arch. 1879. p. 175, No. 2; Milchoefer. Die Anfänge der Kunst, p. 45, and Helbig. L'epopee homerique. p. 93. No. 6.

These lions are certainly of oriental fabrication. the statuettes could also then be objects imported from outside. This hypothesis has presented itself to the minds of some archaeologists, that have seen these figurines. We do not share that opinion.[2]

Note 1.p.148. Homolle. Bulletin. 1891.p.441. Stais. Deltion. 1892. p. 9. Also to [illegible] inclined to that opinion. (Revue des etudes grecques. Vol. IX. p. 445-446).

Note 2.p.148. Our impression is that of MM. Brückner and Pernice, the authors of the excavation. (Ein Att.Fried. p. 129-130).

The ivory came from Africa; but one knows from the tombs what consumption was made of it in Mycenaean Greece. For the following period the Iliad and Odyssey attest that in the world in which the Homeric poets lived, industry commonly used ivory for decorating jewels, arms and furniture; the question is then not that, it is entirely in the poseand the characted of the figure. What must be found, if one wishes to establish that these statuettes were not modeled in Greece, are oriental prototypes of which these are copies. I have sought those protypes in vain in what remains from Egypt and Phoenicia. This is not the pose that Egypt usually gives to its figures; men and gods are almost always represented there in the attitude of walking, the left foot in front; it is further rare in its statuary for women to appear nude, that they do not at least have a light drapery fixed around the hips. If in the ivories of the glass cases of the Egyptian museum in the Louvre are ivories, that approach in pose and appearance the statuettes of the Dipylon, nothing indicates their source or age, and some seem to be of quite a late epoch; it further seems that those may be handles of mirrors, of knives or of spoons; now those Attic statuettes by the uniformity of their attitude and the plinth that supports them, can scarcely have been merely idols, and they have nothing that recalls the Egyptian images of a divinity.

This prototype that we have demanded from Egypt without result, Phoenicia neither supplies. Clothed in a long peplos, is presented the female figure in monuments, whose Phoenician origin is undoubted.[1] On the other hand, there is a sensible relationship between the statuettes of Athens and the image of a woman modeled on an ivory plaque, that we formerly classed in the number of works, that could be placed to the account of Ph Phoenician workshops,[2] but we do not believe that this assignment should be maintained. The plaque came from the necropolis of Camiros; now that we have better studied Grecian archaism, we should incline to reduce by much the part proper to give to Phoenician industry in the inven ory of the equipment of the most ancient tombs of Camiros. We should not hesitate then to recognize there the work of a Greek artisan.[3] The type reproduced by that relief is foreign to oriental art, or at least is only found there very late, when that could be inspired in its turn by models created by the coast tribes of the Egean sea;[4]

on the other hand it is represented in the oldest cemeteries of the Cyclades by numerous examples, by those flat figures of very rude work and cut in marble, some examples of which are also found at Delphi and Athens;[5] it is also by Cypriote terra cottas, that do not belong to a later antiquity.[6] The ivories of Camiros and of the Attic tombs are distinguished from the primitive statuettes only by the use of a different material, by a fabrication already more skilful and by an unique trait; in the figurines of Amorgos and o Antiparos, as in those of t the cemetery of Alambria, instead of the arms being pendent a and attached to the haunches, they are crossed on the chest beneath the bosom. Like that is the same complete nudity, the same appearance of absolute immobility. The resemblance is more marked than the difference.

Note 1.p.147. Histoire de l'Art. Vol. III. Figs. 281, 617.

Note 2.p.147. The same. Vol. III. Fig., 618.

Note 3.p.147. See in Bulletin, 1895, p. 289, No. 2., the list of several other monuments, that we believe have been erroneously attributed to the Phoenicians.

Note 4.p.147. Rendered very probable by Salomon Reinach. (Les deesses nues dans l'art oriental et dans l'art grec, in Revue archaeologique. I. p. 378-394.

Note 5.p.147. Histoire de l'Art. Vol. VI. Chap. 9. Sect. 2.

Note 6.p.147. The same. Vol. III. Figs. 374, 375, 379.

This theme of the upright nude woman with arms fixed to the thighs, we find again in a bronze figure of the museum of Athens. The statuette is much corroded, and appears to date in a distant age. The head is borne on a very long neck, and is as if cut with a knife; the nose is placed very high. No cap, but aside from that detail, the idea of the fabrication strongly recalls our ivory figurines.[1]

Note 1.p.148. De Ridder. Catalogue des bronzes trouvees dans l'Acropole d'Athenes. 1896. No. 771.

The type presented to us by the relief of Camiros, the statuette of the Acropolis and the statuettes of the Ceramicos thus appear to be nothing but a variant of tha created by the tribes, whose work is especially known to us by certain cemeteries of the Cyclades. The fabrication of those images was intimately connected with the most ancient of all religions, the worship of the dead. It was followed beyond even the Mycenaean age. On

One of those figurines has been found at Thera in a tomb, that enclosed a vase of geometrical style. All those statuettes fo found in the tombs, that are of marble, clay or ivory, can only be images of a divinity protecting the dead, images thought to play a part analogous to that filled in Egyptian sepulchres by the figuines of glazed clay, that are called "oushebti" or respondents. One will note the cap placed on the heads of two figurines; it already appears sometimes in the primitive terra cottas, and is a headdress that classical art reserves for divine personages.

Note 2.p.148. Sitzungsberichte of Academy at Vienna. 1873. p. 240.

If it be proper not to see in our figurines Phoenicial importations, but the development of a type created by the Greek imagination, it must be there ir a sensible relation between the style of these statuettes and that of the other works, that one is correct in attributing to the same period. Now that resemblance exists; it will strike the eyes of every critic, who guards himself against what is called the oriental mirage.[2] Doubtless the sculptor is here in advance of the ceramic painter, as the goldsmith of the Mycenaean age was; but aside from that, there is in both the same interpretation of the human form, the same elongated proportions, the same awkward rendering of the lines of the face, the same horizontal shoulders, the same triangular shape of the bust, the same conventional contraction of the body at the top of the hips, the same negligence in presenting the hands and feet. If one considers the only accessory comprised by the state of entire nudity, there is the same agreement; the ornament of the cap of the principal figure is nothing but the fret; now this motive is again found on the same vases that accompany these ivories in the tomb from which they were taken.

Note 3.p.148. S. Reinach. La Mirage oriental. 1893.

From the fabrication of these vases, where the geometrical style has not yet attained the rigor of its principle by the insertion of the human figure, we incline to believe that the entire deposit to which belong these ivories dates rather from the 8 than the 7 th century. Our statuettes would then be earlier than the oldest sculptures of colored tufa found on the Acropolis of Athens. The temples that the latter decorated could scarcely have been built before the 7 th and 6 th centuries.

With the ivories of the Dipylon the historian is perhaps nearer the Athens of the Erechtheides than that of of Pisastratos and Hippias; but he cannot regard withindifference the figures in which he believes, that he has to salute the most ancient monuments of Attic sculpture.

The facts are very different in the figurines of terra cotta tha appear to come from Beotia, and that must likewise be idols protecting the tomb.[1] Those dolls, for one can scarcely g give them a different name, have the form of a bell. In some t the legs are attached by a metal wire below that bell (Figs. 28, 29); others have not received that appendage. (Fig. 29). Two clay knobs mark the places of the breasts. By the manner in which the belly of the bell is decorated by designs traced with the brush, it seems that the workman desired to represent the goddess as clothed. The fabrication is singularly more barbaric here than in the statuettes of Athens, and it has been based on the character of the motives that ornament these images, to declare that they are earlier than the vases of the Dipylon; it has been said that the human figure did not appear in the repertory of the motives, that are drawn on the bodies of these dolls. It is necesssary to renounce the use of this argument; the Louvre has recently acquired an idol of this kind, a around which the brush has traced a scene that is one of the favorite mottoes of the painters of the Dipylon, dancing women holding each other by the hands (Fig. 31). Even before the proof was thus made, one could compare these figurines to the Attic vases; it would have sufficed to note the resemblance existing between the rendering of the head in the paintings of those vases and in the modeling of the Beotian statuettes. The same long neck, a cylinder that never ends; the same long pointed chin; the same projection of the nose, that projecting between two great round eyes with no indication of a mouth, gives to the whole the appearance of the profile of a bird. There is in the paintings of the Dipylon such a convention, that is no less naive than that, which on these dolls serves to indicate the a arms, here represented by two rods of clay (Figs. 28, 31), and there being painted on the body of the bell (Fig. 29).

Note 1.p.150. Holleaux. Figurines beotiennes en terre cuite a decoration geometrique. (Monuments Plot. Vol. I. p. 12-42).

These rude images may then be contemporary with the vases of

the Ceramicos, and one cannot be surprised to find them very i inferior in fabrication to the statuettes, that were carved at Athens at about the same time. The precious materials were entrusted only to selected artisans, while the potter manufactured cheaply for the people.

A work of sculpture that can be regarded as nearly contemporaneous wit those dolls is a plaque of terra cotta found at Egina near a destroyed temple, mixed with the remains of all s sorts, vases of the geometrical style broken into a thousand pieces, broken idols, scarabeuses and little enameled earteen pots.[1] The image was made by stamping; it represents a woman in fron view, that a sort of skirt clothes from the girdle to the feet. The upper part appears nude. Both hands are applied to the breasts and seem to press them to force out the milk. The process employed, the rudeness of the execution, the arrangement of the hair, all concur in giving to the relief an appearance of very high antiquity. There are at the top of the plaque two holes, which indicate that it was suspended from a wall. This was a votive monument, and to all appearance was an image of Aphrodite.

Note 1.p.151. Ephemeris. 1895. p.283-284.

If we have said nothing here of glyptics, it is no because there do not exist intaglios dating from the 10 th, 9 th and 8 th centuries; but it is very difficult to distinguish these intaglios from those dating in the Mycenaean age, or from those belonging to archaic Grecian art. When the engraver attacks s stone or metal and only reproduces the forms and types created by the statuary, by suiting them to the narrow dimensions of the bezel of a ring. Now the works of statuary are lacking to us for the entire time, that corresponds to the completion of the epic period. Every criterion thus is lacking for us; we cannot define by certain characteristics, among the intaglios that bear the mark of high antiquity, those which it is agreed to attribute to the period opened by th Dorian invasion. Very few intaglios have been found in the tombs of the age of the Dipylon; to the small number of those mentioned we add one that came from Beotia, a flat and nearly rectangular stone, where the engraving represents a woman clad in a long rope and raising the left arm, faced by two birds symmetrically turned to the outside. (Vignette on p. 153).[1] The theme is borrowed from the re-

repertory of the Mycenaean artists; but the execution is summary and negligent. It is the same for some other stones, that are attributed to the same period with some probability. On so some on which are the figures of men and of horses, it is believed are seen the marks of the procedures in design that characterize the geometrical style.[2]

Note 1.p.152. Collignon. Note sur des fibules a decor grave. (Memoires de la Societe des Antiquaires. p. 55.) Fig. 2. Height of stone is 0.51 inch.

Note 2.p.152. Furtwängler. Königliche Museen zu Berlin. Beschreibung der geschnitten Steine im Antiquarium. 71 plates in phototype and 120 figures in the text. 1896.

Then we should refer to another time by all means the sequence of the history of glyptics. What completely justifies the part that we have taken, is that nowhere in the two poems is a mention of a seal. When Ulysses is ready to depart from Alkinoos, and is occupied in placing in safety the presents made to him by the Phaeacians, he shuts them in a coffer; but he does n not have th idea of attaching his seal; by means of a complicated system of knots he seeks to prevent the opening of the c casket during his sleep in the course of the voyage.[3] The procedure that he employs gives reason to think, that men very rarely used a seal in the society where Homer lived. Why had they renounced the practice, very general in primitive Greece, and that later would become in current use? We do not know; but the indications to which we have called attention appear to render probable the hypothesis of a decadence and temporary eclipse of glyptics, which would reappear with sculpture after the 7 th century.

Note 3.p.152. Odyssey. VIII. 446-448. Yet Furtwängler mentions some seals among the intaglios, that he attributes to this period. (Nos. 78, 79, 81, 88).

I is with painting as with glyptics. No stroke of fortune h has preserved to us for this period the remains of frescos of the kind of those, which by a sort of miracle, have been found beneath the ruins of the palaces of Tiryns and of Mycenae. On the other hand, one finds nothing in either poem, that is related to the art of the painter. It is probable that in the interiors as on the facades, the plastering received a coloring, and that grounds of some extent were enclosed or divided into

panels by bands, whose color was more vivid than that of the ground; but no allusion is made to scenes that decorated the princely house. This silence is explained; then the ceramic painter no longer knew how to give any decoration to his vases other than geometrical ornament, and then could not be found in Greece artists, whose brushes were capable of representing in the panels of the megaron, as at Tiryns, the chase of the w wild bull, or as at Mycenae, processions of horses and warriors, of scenes of combats.

Chapter IV. Industrial Arts.

I. Ceramics.

One recalls the gray pottery of Hissarlik, whose hemains are found in great abundance on the Trojan hill, from the second to the fifth cities.[1] This is a pottery of paste maxed with small pebbles, with thick walls fashioned by hand and decorated by incised designs filled with white clay.[2] The same rustic pottery also abounds at Tiryns and Mycenae; it is le s rude there, and is there found with vases decorated by the brush. Otherwise only on th sites of prehistoric cities does it appear, in company with the works of a more skilful art.

Note 1.p.154. Histoire de l'Art. Vol. VI. p.895-896. Figs. 442-453.

Note 2.p.154. Athen. Mitt. 1898. p. 111, 118.

On the Acropolis of Athens in the gravel that forms the ground on which were placed the edifices of the 5 th century, have been collected fragments of these monochrome vases. There is one where a projection from the massive wall is pierced by one of those holes through was passed a cord, before men knew how to form the ears from the body of the vase. (Fig. 33). The appearance is here very primitive. The vase perhaps dates back at the time when the Acropolis received its first inhabitants; but one would no attribute such high antiquity to fragments on which are incised triangles, concentric circles, chaplets of whorled leaves (Fig. 34); those motives rise in light on a ground of well polished brown clay.

The presence of these fragments in the subsoil of the Acropolis furnishes no indication of date; but even that pottery is found in the tombs, of the Ceramicos of Athens with painted vases. Here is a fragment of an aryballos with figured surfaces; The workmen stamped in the clay an ornament whose curve is scratched in fine lines, and makes one think of certain shells (F (Fig. 35).

Until when was this fabrication prolonged? It had not fallen in (desuetude, when after several centuries men painted on the clay. It continued to supply vases for domestic uses.[1] It must have been particularly active in western Greece, where men only commenced very late to employ painted pottery. But even in centres like Athens and corinth, it has always been represented, at least by such vases as the amphora and the pithos, which

were intended to contain oil, wine, and sometimes the remains of the dead (Fig. 36). Those vases often reappear as well as a decoration executed with the point or stamped with a roller; but we shall give to it but a limited place in our researches. The painted vase alone is a work of art.

Note 1.p.155. Athen. Mitt. 1893. p. 139-140. The same pottery is found at Eleusis in a tomb with painted vases, that like those of Salamis, form the transition between the Mycenaean style and the geometrical rectilinear style.

For a long time the archaeologists had eyes only for the beautiful works of the ceramists of the 5 th and 4 th centuries; about 25 years since they began to distinguish certain vases, that although from differen sources, appeared to them to present enough traits in common to form the most ancient of the groups, that had to be studied by the historian of Grecian ceramics.[2] That place was assigned to them because of the character presented by their ornamentation. Those vases were all executed on the wheel with clay skilfully prepared. The forms a are varied, with construction already skilful and often happy; but on many of those pieces all ornament is what is termed geometrical. It is only formed by combinations of lines, especially of straight lines, that run parallel to each other or meet and intersect at different angles; not an image of a plant or animal, not a motive that even distantly recalls the world of life. The artist seems to ignore this world; one would say that he had never known only the abstract form, such as he drew it, in the minerals that crystallize, the chemical affinities, particularly such as the mathematician presents in the tracing of his figures. Among the vases of careful execution, but few have thus abstained from making any allusion to the existance of organized beings; but these are those that it is proper to select as types of this very peculiar style, because the system has been applied to it in all its vigor (Fig. 37).

Note 2.p.155. The merit of having after 1870 first called attention to that class of vases, and for having formed a separate class of them, belongs to Al. Conze (Zur geschichte der Anfänge Griechischer Kunst with 11 plates, in the Sitzungsberichte of the Academy of Vienna, Phil.hist., Classe. Vol. LXIV. p. 505-538). Conze had the merit in an entirely new matter, of a seeing correctly at first step. In a second Memoir, he replied

to serious objections, that had been made to it, especially by Lindenschmidt. (Sits. Vol. LXXIII. p. 221-250). Conze found a more competent opponent in Helbig. (Asservazioni etc. 1875. p. 221-253); he replied without abandoning his thesis, but softening what he had stated too absolutely, and defining the terms with more precision. (Oggetti, etc., Letters of A. Conze to W. Helbig. Annali. 1877. p. 384-397).

The decorator could not adhere long to that too narrow and paradoxical method. However ingenious he was, he never derived from linear ornament but a small number of distinct arrangements. How did he resist the timptation to remedy that poverty by seeking elsewhere what was not given to him by the play and confusion of all those curves and straight lines? Mixed wi with those abstractions, the least bit of reality assumed by contrast a singular value; it broke the monotony of this decoration, that became heavy and complicated without ever succeeding in being animated.

If life thus reconquered its rights, this is at first timidly and almost silently. There is a certain vase on which it is represented only by one or two paintings of very small images of aquatic birds or of goats (Fig. 38). Elsewhere one sees those images already assume more importance, either in themselves or by the place assigned to them. Swans and ibexes form files that fill one of the bands on the body (Fig. 39), or indeed one sees appear there other animals, that require more space, like the horse (Fig. 40). There are also objects where the geometrical design seems to be simplified to further serve only to surround the spaces on which more at their ease the bird and the horse (Fig. 41) or the goat and the bird. What all those vases otherwise have in common, whatever the figures scattered over them with the brush, is that these are not engaged in an action, that could interest the mind. These are there only to amuse the mind, like the concentric circles and the frets; they are merely ornamental.

Finally, we come to works on which the two series of motives existing on vases of the second species have attained their full development. The combinations of lines always retain the same place there. Due to the precision of drawing, they offer all t the pleasure that this system of decoration comprises, where it is mos skilfully conceived, but at the same time the images

that are enclosed in the compartments reserved begin to take an entirely different character. Even the animal is more than accessory. The human figure appears in the first place, it is multiplied; it shows itself under different aspects in scenes, such as representations of funeral ceremonies and of combats on land or sea (Fig. 42).

It seems that in Attica the painter made this decisive step. Nearly all the vases of the geometrical style with figures were found in tha country, some of them at Egina, Eleusis, and in the suburbs of Athens, mostly at Athens itself in the cemetery of the outer Ceramicos adjoining the gate called the Dipylon (double gate). These vases are indeed the product of Attic industry. Why should one suppose that they were brought by commerce from outside? One cannot allege the slightest indication to support that hypothesis. Where is to be sought the centre of production? How is it to be explained that this place, from which come such a great quantity of vases stamped with the seal of a very particular taste, should not have retained in its cemeteries some examples of its own manufacture. The supposition is the more improbable, since the soil of Attica furnishes an excellent clay. What proves that the quality of the earth there very early gave rise to the industry of the potter is, that even this name of ceramicos, that an urban district seems to have borne in all times; it signifies "the quarter of the potters." Finally some of these vases have a height that even excludes the idea of importation. I mean those that stood over the tombs, where they performed the purpose of steles (Fig. 42). The workman could give them those dimensions and weight only because he knew tha he had only to transport them to a sepulchre quite near his workshop. Placed on a broad plank, those enormous articles were adapted to pass without accident over a small dis ance; but the difficulties would have been almost innumerable, if it had been necessary for them to make a long journey by land o by sea.

It is true that one of the most careful works o this fabrication, the vase of Ormidia, came from a Cypriote necropolis, and there have been collected in the Peleponessus and even in Sicily some fragments of the same pottery, this is because that after this epoch the workshops of Athens labored for export.[1] Outside of Athens, this pottery is only found in isolated examples

in countries very distant from each other. If Beotia also fabricated numerous vases with figures, one feels in them the imitation of types created by the potters of Athens.

Note 1.p.160. Histoire de l'Art. Vol. III, p. 702-703 and Fig. 514.

With the vases of the Dipylon the evolution of the geometrical style reached its limit. From the moment that the image of man entered the field of the vase, it could not fail soon to invade it entirely, or at least to make itself the best part t there. Occupying more space, it is enlarged; it will be more at ease for varying its attitudes, and to express more feelings and ideas, due to the diversity of subjects. To that was especially devoted the efforts of the painter, and the linear ornament, which was at first the principal thing, no longer served bu to decorate the parts of the field that the figure was willing to abandon.

If there be a clearly defined group, it is then that forming the painted vases reproduced above and those resembling them: but what place do these vases occupy in the long series of the creations of Grecian genius, and what is their relative age? That is the question proposed at the beginning of this study; it is necessary to reply to it.

When men commenced to call attention to these monuments, Mycenaean civilization had not yet risen from the earth. They had no information on the prehellenic period, they knew nothing of the ceramics, whose products were preserved in the tombs of Mycenae and of Ialysos, or their fragments strew the soil of the Cyclopean enclosures. In those conditions, it was natural for them to commence by attributing to the vases of geomertical design the highest antiquity, that the mind could t then conceive.

On the morrow of the excavations of Schliemann, the point of view had changed; science found itself in presence of creations of ceramics unknown till that day. Which were most ancient, the vases with geometrical decoration or those characterized by the use of a decoration, that demanded its favorite motives from t the imitation of plants and sea animals? They would have been much embarrassed to decide the question of priority, if they had been compelled to base their judgment only on the direct c comparison of the monuments. Assume a critic, that for both

kinds canno' know where and in what company they were collected; hesitation will be allowed to him. Placed near the vases just represented, the vases termed Mycenaean would seem to bear the marks of a more advanced art. What removes all uncertainty are the circumstances themselves of the discovery. Nothing is better established than the civil condition of the vases which have as ornaments branches of flowers, the ivy and the algae, the octopus and the nautilus; they are legacies from the societies that lived in an age, that separates from historic times that series of migrations and conquests, which tradition calls the return of the Heraclides and the Dorian invasion. As for the vases where the ornament is entirely linear, they are not found mixed with the reliefs of that first age; there is no remains of them in either the ditches of the Mycenaean acropolis, at Vafio, Spata and Menidi, or at Salysos. In the citadel at Mycenae, hardly a few pieces have been collected on the surface of the ground. The only point where those fragments appear in number is the site of the palace; but there only in a layer composed of the ruins of that edifice have they been collected; among the rubbish of the huts built over its ruins, perhaps long after the destruction of the royal residence. It is the same in the lower city, one has found lessons of that sort neither in the domed tombs, nor in those excavated in the rock; on the other hand, they have been not rare in the rubbish obstructing the entrances of all those sepulchres. Those appear to have been violated for the most part even in antiquity, doubtless when the Dorians were established at Argos, and the decadence of Mycenai had commenced. Then were mixed with the earth removed by the hands of pillagers the fragments of vases, that tended to replace the ancient pottery, whose fabrication was going to end.[1]

Note 1.p.182. Tsoundos. Mycenai. p. 237. Letter of Feb. 15. 1884. "I have found," Tsoundos wrote me, "many fragments of the geometrical style thrown as by chance into a ravine north of the city, below the ruins of an edifice"(Steffen, sheet 1, at the left of the torrent Asprochoma, point 170, where is inscribed the indication "Antike Stutzmauer); "I also found two entire vases of the same species in a ditch near the gate of the Lions. This was a very simple tomb, without walls or covering, and the bones of the dead had not passed through the flame."

If one seeks a criterion that permits more precision, it is found in metal. With the Mycenaean vases one finds only bronze besides the precious metals; but arms of iron are furnished by the tombs of the Ceramicos of Athens, to which are due the largest and most beautiful of the vases with geometrical decoration.[2] Now iron does not appear, and still it was entirely a rarity toward the end of the Mycenaean period. At the time when originated the songs that entered into the composition of t the Iliad and the Odyssey, it is still not much less general t than bronze; it neither supplies the warrior with his cuirass, his sword, or the point of his spear. The vases with which we are here occupied, contemporaneous with the use of iron, are then later than the vases fashioned by the potters of the age of bronze.

Note 2.p.162. Rayet and Collignon, Histoire de la ceramique grecque, p. 23-24. Dümmler, Zur Nekropole am Dipylon. (Athen. Mitt. 1888. p. 297-300.). Brückner and Pernice. (Ein Attischer Friedhof. p. 139-140).

If to entirely justify this assertion other proofs are required, one can add that the vases with geometrical decoration are connected by insensible gradations to those called proto-Attic, proto-Beotian, proto-Corinthian, which themselves have intimate connections with the vases with black figures of the 6 th century, that are dated within a few years by the inscriptions traced on them and the subjects represented. It is the same for the Mycenaean ceramics. That replaces is connected with its predecessor only by very loose bonds; those threads are so thin that men have had some trouble to perceive them, which caused to be thought that there was in Greece at a certain time an abrupt and almost complete interruption of industrial activity. If that hypothesis must only be admitted under reserves that are indicated, it is no less established, that even by the fact that it has been able to seem probable, the art from which was derived the ceramics of Mycene, was rejected in a very distant past.

It is natural to suppose that the most ancient of the vases of the so-called geometrical style are those on which there a are only intersections and combinations of lines, with no or nearly no allusion to the world of life; it seems logical also to see in the appearance of the figures an advance, or at least

desire to advance, and to regard as more recent than the others, those monuments where figures ente into the composition of a scenes, whose sense may be seized in spite of the awkwardness of the drawing. On that account, these are the great vases found in the cemeteries of Athens and of Eleusis, which form the last terms of this series; but while admitting the extreme probability of this hypothesis, it is important to state, that in the same tombs on which were set the amphoras and crateras for personages, one finds pieces of smaller dimensions, that have no ornament other than linear. (Fig. 43).

Yet there is one trait by which is emp asized the close relation that connects the vases of the Dipylon with those on which the ornament was not allowed the insertion of the figure. This trait is the instinct of rhythm, a rhythm that recalls that of architecture. On the pieces where there are no images, as on those where images assume most importance, the entire visible surface is divided into several spaces by bands of deep black, that toward the bottom and top of the body are reinforced by a row of thiangles or sawteeth. (Fig. 44). The horizontal bands thus created in their turn are divided by vertical bars into panels, that recall the metopes of the Doric frieze. In t the interior of each of those spaces, is a motive, that occupies its middle. This is a cross surrounded by concentric circles (Figs. 37, 45), a fylfot (Fig. 52), or four leaves arranged in form of a cross (Figs. 46, 50); also a lozenge, within four triangles. (Figs. 47, 51). Elsewhere is a bird (Fig. 41), a horse (Fig. 40), or two horses facing each other (Fig. 49). Finally, where the human figure plays an important part, these spaces are larger. The images there are always enclosed in the same fashion; but they occupy all or nearly all of a band. The chariot races and files of ships extend around the vase without the vase without interruption, toward the bottom of the body; the upper part of that is devided by the strong projection of the ears into two panels in which is displayed the pomp of the obsequies. In the principal scene the bed on which the dead rests is placed on a chariot, forms the centre of the scene and dominates the personages ranged around it. Those are all of the same height and in the same attitude; they are in the same number on each side of the catafalque. Everywhere prevails an exact symmetry. (Fig. 42). The same tendency is manifested in

the skilfully managed contrast, on the one hand between the li lights on which the figures are detached, and on the other the dark zones that cover the entire foot of the vase, as well as the ample fret that ornaments the border of the cratera or the neck of the amphora. There is pursued a very thoughtful method; whatever the composition, the painter no longer has much to l learn. If that painter already has a correct idea of the conditions of the art, which causes his work to retain in the entirety an entirely primitive character, that is the character of his design. The painter depends on the potter. The latter employs a clay with grain as fine as in the most careful Mycenaean vases. His vases are of a yellow tone, more or less rosy, on which is vigorously prominen the black of the painting. The forms are less numerous than those of the Mycenaean epoch; they comprise the cratera and the amphora as recipients of great capacity, the oenochoe as a vase for pouring, the skyphos as one for drinking, and the pyxis as a jewel case. When one compares these to the Mycenaean ceramics, he feels himself in the presence of a different esthetics. Certain forms entirely disappear, like the tall vase with long and slender foot,[1] the elegant "aiguire" with round lip,[2] the vase for the saddle,[3] and the horn for drinking.[4] The rounded, short and squat shapes of the Egean potteries give place to larger and more massive vases, in which the straight and cylindrical construction dominates. The Mycenaean hydria and oenochoe have short necks, wi wide shoulders and round sides.[5] The hydria and oenochoe of t the geometrical style have the neck very long in form of a long tube, scarcely any shoulder and straight sides. Mycenaean vases are generally of moderate dimensions, that make them easily h handled. Here one finds himself in presence of vases much larger and difficult to move. They sometimes become colossal.[1] "Of two amphoras of the museum of Athens, one has a height of 5.25 ft. and the other of 5.91 ft. To shape and burn pieces of such height required rare mastery in the workman. One of the peculiarities that distinguishes the amphoras and crateras is the original arrangement of the ears (Fig. 49); they take the form of a pair of horns, that are reversed and curve toward the ground, like those of the ram. (Catalogue no. 517).

Note 1.p.164. We must thank M. Collignon for the courtesy with which he has placed at our disposal the drawings executed by h

him, when he prepared his Catalogue des vases peintes du musee de la societe archaeologique d'Athenes. (Paris. 1896. In Bibliotheques des ecoles francaises de Rome et Athens, part 3.).

Note 1.p.166. Histoire de l'Art. Vol. VI. Fig. 492.

Note 2.p.166. The same. Fig. 486.

Note 3.p.166. The same. Fig. 487.

Note 4.p.166. The same. Fig. 473.

Note 5.p.166. The same. Figs. 438,454,466,479,483 etc.

Note 1.p.167. E. Pottier. Musee de Louvre. catalogue des vases antiques de terre cuite. Part. 1. p.214-212.

Compared to his predecessors, the potter is then rather in advance of them; but one cannot say as much for the painter. At least on the vases by which the series is closed, there are ambitions unknown to his predecessors, none of them had yet attempted to represent such simple scenes as those decorating the enormous vases made at Athens for to be placed on tombs. By the boldness of that attempt and by the happy harmony of the general arrangement, the painter of the Dipylon announces the future; but his execution does not correspond to the conception. Very firm where it only consists of that play of lines which interests the eye, it becomes childish and almost barbaric where the painter undertakes to imitate living forms. There is then to be distinguished in the work of his brush, the purely linear design and that of the figure, the motives of the first are more or less developed, and are formed on all the vases without exception, that compose this series; on the contrary, the figure only appears on certain of these vases. Alone because it introduces in the work of the artist the image of man, the image expressive among all, it is more interesting in this decoration; but it does not remain less established, that when this style was constituted, if did not use the figure, and it always knew how to do without it; it is wanting on many vases found in the tombs of the Dipylon and contemporaneous with those in which it holds more place. Likewise where it appears to have more importance, the figure then always retains in this style the c character of an adventitious and belated element.

No description can define all the motives comprised on this type of linear ornament. Thisi motives are first the horizontal bands and vertical bars connecting them, bands and bars that supply the principal lines of the decorations, that are as its

framework and skeleton. In the bands and in the spaces so enclosed, the brush is anxious to leave no vacancies, and has thrown a very dense filling of dotted lines, oblique hatchings, chevrons, zigzag braids, simple or cut triangles, also those with opposed vertexes, lozenges, chessboard squares,and simple or bent crosses. The fret is one of the motives for which the artist has the most marked liking. Sometimes the fre develops entirely around the circumference of the neck or of the foot. (Figs. 42, 50); some traces in one of the panels of the body it appears only in a fragmentary state (Fig. 38). Its esign is sometimes very simple, as it will remain in classical art; elsewhere it presents projections that make its outline complex. (Fig. 51). One will note the frequent use of the fylfot cross made by the decorator (Figs. 40, 42, 52). One asks in that case, what is the origin and meaning of this motive? Is it merely derived from the fret, a fret cut into two parts, that have been brought together? Is it a symbol, that is merely a double of the wheel, which like that represents the sun in its daily movement in its progress through space?[1] What causes me to incline to the first explanation is, that one also sometimes finds on these vases and employed in the same manner as the fylfot, another motive, which with its 16 branches is evidently only a v variant of the fret (Fig. 44). On the other the fylfot, which is unknown in the neolithic epoch, is neither found in Egypt, Chaldea, Assyria, nor in Phoenicia, while one sees it appear at Hissarlik on a lead statue and especially on the spinning disks. It is lacking on Mycenaean pottery, but at about the time that the Greek potter lavished it on his vases, its use is common to the prehistoric peoples of north Italy, the valley of the Danube and Scandinavia. Greeks and Romans will receive it in the heritage from theeir distant ancestors, with them it is found on the monuments, where according to the place it occupies and the accompanying inscription, it seems to be only a mere ornament. Finally, it is certain that in India and in the extreme Orient, among the Buddhists, under the name of swastika it has a religious signification. The problem is proposed; we do not charge ourselves with its solution.

Note 1.p.169. This is the solution reached by Goblet d'Aviella in the study devoted to the fylfot. (Le Migration de symbols. 1891. Chap. 2). It has been proposed to see in the fylfot a r

reduction of one of the motives dear to Mycenaean art, of the figure of a nautilus with four arms. (Houssay. Les theories de la genese a Mycenes. p. 24, in Revue archaeologique. 1895.[1] The difficulty is that the nautilus is represented with four arms; it is also that the geometrical style did not borrow its motives from the Mycenaean style, and is not a degeneration from that.

All the motives just cited are rectilinear. The curves that dominate in Mycenaean decoration play only a secondary part h here. There is a certain piece where the field has no decoration other than large concentric circles (Fig. 53). On other vases, circles of very small diameter with centres indicated by a point are joined together by tangent curves (Figs. 39, 50); thus one obtains a continuous motive, whose appearance recalls that of the ornament known under the name of continued scrolls. Large circles are found exceptionally on vases, where the human figure appears near that of the horse (Fig. 54); but these are sought in vain on the amphoras and crateras of the Dipylon. There the circle no longer appears as an independent motive; if it still appears sometimes, this is only to fill the middle of the panel; combined with the close web of that compact design, it does not a tract the eye (Fig. 45). Besides the circle, when the geometrical style has reached its full development, it scarcely admits the curved line except in two motives, to which it accords but a moderate importance. One of these is a very elongated oval, that serves as a sort of rosette with 4, 6 or 8 branches; (Fig. 47); by indefinite repetition it also forms a sort of collar, that sometimes surrounds the body and sometimes the foot of the vase (Fig. 55). The other motive is a reversed curve, whose turns imitate those of a worm crawling on the ground (Fig. 51). It serves to fill certain light zones, that the painter has made a law to never leave void.

This spiral of very poor appearance is here the sole remains of those spirals with capricious scrolls, that occupy so much space in the Mycenaean decoration. It has been asked, whether it is not necessary to seek in this curvilinear zigzag the origin of the fret. To obtain the fret it indeed suffices to change into straight lines the regu,ar curves of this spiral; to thus one substitutes a series of right angles for the rounds of those alternating bands. Is this actually the procedure follow-

followed by the ornamentist? The works of the basket-maker, we weaver and embroiderer present examples of the fret in more t than one country, where the system of motives of which it forms a part do not seem to have been preceded by another with a different principle. The hypothesis further has nothing in contradiction with the spirit of the style, whose own character is its very pronounced tendency to stiffen all lines, to give them nowhere the supple flexures, that they present in the world of life. This tendency must manifest itself even where the designer exceptionally adopts something else than straight lines. We have mentioned a motive whose contour offers some analogy to that of a leaf (Fig. 55); but how distant is that analogy! On the Mycenaean vases the leaves are attached to their peduncles and are frequently connected by these to the branch that bears them, and are unequal and tend in different directions, as on the plant. Likewise one divines there behind the rosette the flower that furnished its model. Here is nothing similar; the circular segments that form the points of these stars have an absolute regularity; one would say that they were drawn with compasses.

To practice that kind of design, the hand of the painter contracted habits, that continued for a long time to control its movements. Even when the ceramist of the Dipylon has placed m most of his personages, linear ornament always retains its predominance. Not only does it occupy more space and serve as a frame for the figure, but also that submits to its influence. See this vase that represents two horses facing each other; (Fig. 48); the bodies of the horses are represented by two wide bars parallel to the line of the ground; this is indeed the work of a brush trained in the school of geometrical drawing. The deformation is again more sensible in the human figure. No liberty and no diversity. For all the figures engaged in the same action is the attitude identical. The arms are raised and bent everywhere at the same angles (Fig. 42). The one personage and another, the legs are much too long and are exactly parallel; but especially the torso has a characteristic design. This has the appearance of an inserted triangle, that has for its base the breadth of the shoulders, and as apex the reduction of the waist, here contracted beyond measure. A stick takes the place of the neck and bears the head, that resembles the head

of a bird and on it is represented a great round eye; that head is sometimes surmounted by . tuft of hair. There is a feeling for nature only in the drawing of the lower part of the body. While the arms are nearly rigid bars, one distinguishes neither the elbow nor the wrist, the roundness of the thighs and of the calves is frankly indicated, a peculiarity that allows to be foreseen the insistance with which among this people, archaic sculpture in its first attempts will emphasize these same projections of the muscular mass (Figs. 58, 59). This is striking if one compares with the most ancient statues the image of the dead lying on his state bed in several paintings from the Dipylon; it is at a larger scale than the images of the living, tht surround the catafalque, which has permitted giving greater emphasis to certain details (Fig. 56).

This trait is the only one in the painter, that evidences a glance cast at the living model. Excepting that the treatment of the figure is schematic; the ceramist only desired to recall to the mind the object seen; his ambition was not to attempt to present a faithful copy of it. See the persons grouped around the corpse. All that the painter proposes is to define well the function of those personages. He attains that result by t the movement given to the arms. These are merely lines of uniform width everywhere, that outline trapezoids above the most ungraceful busts; but the spectator being familiar with those scenes of mourning, has no trouble to understand what they are doing. Both hands meet near the top of the head and are occupied in tearing the hair, no error in the meaning is possible. Likewise for the sex; when it is marked for the women, this is by the indication of the breasts. On most figures these are r represented by two points projecting on the bust, one at the right and the other at the left (Fig. 6); but elsewhere has b been taken, even a more awkward method. The two breasts are placed on the same side, one above the other (Fig. 5, the woman at the top and on the right). Provided that he has shown both of those organs, the designer believes that he has done his d duty. As for the man, when he distinguishes them from women, he does this by the dagger attached to the belt or by the long s shield with two notches in the sides, beneath which he conceals the body; the sexual parts are but exceptionally indicated on the vases, that appear to form the close of the series (Figs.

57, 66). The head is sometimes covered by a helmet with a long crest (Fig. 58).

In most of these paintings, neither on the men nor on the wo women is a trace of clothing, and yet it is improbable that at Athens the relatives of the dead were nude at the funeral rites; no text makes the least allusion to such a custom. By a method of simplification is explained that suppression, the designer judged useless the effort, that would have been imposed on him to show the clothing. All that he proposed to himself was to cause to be understood, that around the corpse were men and women, who took the part that custom assigned to them in the performance of the mortuary rites; the indication of the breasts and of the weapons sufficed for this with that of the movements.

What completes the pr of that the Athenian women and men did not then go entirely nude through the city, as the negroes did in the tropics, as a dancing chorus represented on another vase of the same fabrication (Fig. 59). Men and women hold each other's hands and form a circle. Here it is still by the sword supported from the belt, that the men are recognized, and who seem nude; but what defines the women are not the breasts, assumed to be covered by the dress, a sort of checked skirt, that falls from the waist to the feet and conceals them. This costume is that worn by the women in the paintings, the ivories a and intaglios of Mycenae. One does not find here that arrangement like a belt and those superposed floating draperies, that give the robe such a singular appearance on those monuments. What are different are the interpretation and the rendering.

To give a reason for the apparent nudity of the personages, it has been desired to resort to the hypothesis of the imitation of a foreign model. In these figures with breasts uncovered and pendant has been sought a memory of the images of women traced by Egyptian art.[1] That scarcely represents her as nude; but under the transparent fabrics covering it is permitted to appear the relief of the bosom and all the lines of the slender and delicate figure.[2] To discard that conjecture, it suffices to compare the pretended model with said to be a copy of it. Convention is not the same in Egypt and in Greece. The figure being frankly seen from the side, the artist shows bu one of the breasts, that is profiled on the contour of the chest. On

On one vase the torso presents itself in front, flanked by two breasts. That is an entirely different system. If when the painters of the Dipylon created their type of women, there had been under their eyes the Egyptian type, they would not have wandered so far from it, naive as they were. They would have been incapable of reproducing the elegance, but would have applied themselves to retain the general arrangement in even their awkward sketches; we should find the fundamental data of the exotic type, although spoiled and made heavier.

Note 1.p.175. Kroker. Die Dipylonvasen. p.105-106. (Jahrb. des K. and D. arch. Institute. Vol. I. 1886).

Note 2.p.175. Histoire de l'Art. Vol. I. Pl. XII and Figs. 99, 486, 524.

Note 1.p.176. Furtwängler like us explains this [illegible] of nudity. (Archaeol. Zeitung. 18885. p. 136).

If one desires the authors of these paintings to be inspired by the forms and conventions created by an earlier sculpture, it is unnecessary to seek in Egypt the models that had that influence. What most resemble the figures drawn on these vases are the statuettes of limestone and of marble, that the inhabitants of the islands of the Egean sea deposited in their tombs in the course of the primitive age;[2] there are also golden plaques found at Mycenae, which represent a nude woman, on whose head are placed doves.[3] From the 10 th to the 8 th centuries, the images that served for domestic worship must differ sensibly from those in use during the preceding period. Now if one compares these figures to the images of the pottery, he finds that the analogy does not rest on the fact of the appearance of nudity: it likewise depends on many peculiarities that characterize the mode of presentation. Thus in the paintings as in the plaques of Mycenae, the chest and the abdomen are shown in front, while the legs and head are in profile. The legs are parallel to each other: the feet both equally support the weight of the body. Whether these models are in stone or metal, the face in all has that appearance of the head of a bird, that it presents on the vases, an appearance due to the exaggeration of the projection of the nose; that makes a very acute angle with the forehead and the mouth. Also on all a great round eye occupies the middle of the circle or irregular oval to which is attached that sort of beak. If the ceramist of the Dipylon had

under his eyes images of that sort, one understands what he remembered of them, when he commenced to mingle the human figure with his geometrical decoration.[4]

Note 2.p.176. Histoire de l'Art. Vol. VI. Chap. 8. Sect. 2.

Note 3.p.176. The same. Figs. 293, 294.

Note 4.p.176. Helbig. L'epopee homerique. p.47, 48.

The conventions of perspective are here those that we have already observed in the works of other primitive arts. The designer everywhere superposes some of the persons, that he desires to be seen placed as beside or behind the others on the same horizontal plane. One will obtain a complete account of t the procedure if he studies the arrangement of the scene that represents the exposition of the corpse (Fig. 56). This is extended on the state bed. See how the workman has proceeded to indicate that the relatives are grouped at the four sides of t the couch. Those present are regarded as standing in front along one side of the bed, he has placed below the verticals. At the two ends of the line the figures are smaller in dimensions; if they are so reduced, this is to leave to the painter the sp space needed for two persons, one at the head and the other at the foot of the bed. Finally, over the bed is another series of figures; all those seated on stools. No indication denotes their sex; but one is tempted to believe that this group is that of the women of the family, who sing and resume at intervals the chant of mourning. Their post was behind the bed. The checked tapestry that covers the bed seems held vertical like hangings fixed vertically against the wall. The dead must have been laid on his back; he shows his two legs and two arms, as if he rested on the left side. It is the same where the cars are represented. An open balustrade at the two sides borders the narrow plank on which the driver stood.It would have been too great an effort to seek to show the lower part of the legs through the openings of the lattice. They preferred to raise the figure by the height of the railing; it was then so placed that the feet of the personage would seem to rest on the railing of the balustrade (Fig. 7). In many of these cars the wheels are not connected with the cart of the carriage; a space separates them. (Figs. 6, 7). Some seated persons have only one leg; the other is omitted, that is supposed to be covered and concealed by the one presented to the view of the spectator.(Fig. 56).

However imperfect was such a method of drawing, these painters no less succeeded in placing in their picture more variety, than one would have expected from an art that had such weak me means at command. The representation of the obsequies with the two successive acts into which is divided this drama of grief, already comprises very varied attitudes and movements. Besides the scenes that we have indicated, and which are again found on all the great vases with a funerary purpose, on some of them o one meets with groups, that the workman presumed to add to those of his ordinary programme. Here is a woman holding a child by the hand and leading it to a mortuary couch, as if to cause it to see the face of its father for the last time. (Fig. 6). There is seated a woman holding a child on her knees; she only is associated by here presence with the mourning of the family. (Fig. 60). In the line of cars the drivers of the cars most commonly have their war equipment; the body is concealed by a great shield with notches in the sides (Fig. 7). Otherwise they seem nude, and do not even have the dagger at the belt. Sometimes there is an alternation of these two types.[1]

Note 1.p.178. Annoll. 1872. Plote I - 1.

The life of seamen with its hazards and its adventures has furnished the ceramist with another se ies of themes; he has often represented ships under way and driven forward by the strained arms of the rowers, (Fig. 49), ships fighting with each other, ships with decks cove ed by the dead, while the sea rolls around them corpses which the fish prepare to devour. (F (Fig. 61). These maritime scenes have their places on the enormous vases set over the tombs. Among the fragments possessed by the Louvre, and where are drawn vessels under way, there are many tha by the thickness of the clay show themselves to have made parts of those great pieces with a funerary destination. They represented vessels as they figured cars, to replace here the dead in the conditions of his mortal life, as a skilful d driver of horses and a bold sailor. Member or chief of a naucrasia, he was distinguished by commanding one of the coast g guards, as we would say, that policed the coasts and ports of Attica, who protected them from the incursions of pirates from Phoenicia or the islands of the Archipelago.

To a different category belongs the sole vase, nearly complete and decorated by an episode from this chapter of the reper-

repertory. This refers to a pitcher, whose truly elegant form seems boorowed from a metal vessel. (Fig. 62). The scene here extends entirely around the body. What the painter desired to represent is an attempt to land, perhaps the disembarkation of pirates, that repulse the inhabitants of the country so menaced (Fig. 63). No line marks the separation of the land and sea; but there are warriors at right and left of the ship, which assumes it engaged in a creek or the bed of a river. The steersman has his hand on the wide oar and performs the office of a rudder; he endeavors to turn the ship so as to facilitate the defense or to prepare for flight. The two soldiers that represent the crew are in a dangerous situation; they seek to face all sides with the sword, spear and bow; around the galley the wounded are seen to stagger and fall.[1]

Note 1.p.179. Furtwängler. Griechische Vases der sogenannte geometrische Style. (Arch. Zeit. 1885. p. 132-134). On the images of ships and of maritime scenes found in the paintings of the vases of the Dipylon, also see Cartault. De quelques representations de navires empruntees a des vases primitifs provenant d'Athenes. (Monuments grecs publies par l'Association pour l'encouragement des etudes grecques. 1882-1884. p. 33-57. Plate IV); Pernice. Ueber die Schiffsbilder auf den Dipylonvasen. (Athen. Mitt. 1892. p. 285-306). Cecil Torr. Les navires sur les vases du dipylon. (Revue archaeologique. 1894. p. 14-27) The next volume of Memoires de l'Academie de Inscriptions will contain a study, that M. Helbig has devoted to the same subject under the title:-- Les navires sur les vases du Dipylon et les naucraries.

If on this vase the principal scene is interesting by the complexity of the scene that it traces, the accessory parts of the decoration present details no less singular. Around the neck is a man between two horses that he holds by halters; the execution is here more careful than that where this group alone breaks the monotony of the geometrical decoration (Fig. 48). The man has a dagger at the belt, and on his head is a helmet, whose plume falls behind. On his shoulder is a motive frequently found with the ceramists of the archaic age;[1] It is the chase of a hare by coursing dogs. (Fig. 54).

Note 1.p.180. Arch. Zeit. 1881. p. 83 et seq.; 1883, p. 155, 181.

Another favorite theme of the painters of the Dipylon is the representation of a darcing chorus (Fig. 59). It is found with many curious developments on a vase of Athenian origin, in which even the form of the piece and the boldness of the curves of the ears permit one to recognize one of the more recent products of that fabrication (Fig. 65). The decoration is divided into two bands. In the upper band and separated by quatrefoils, are only animals, aquatic birds, stags and hinds, whose attitudes present a variety and suppleness, that one is not accustomed to find on this pottery. The lower band forms a scene cut into two parts by the ears. In one half the band are only entirely nude men; the sexual parts are indicated. Two of those personages, each holding in the hand two spears and covered by a great shield, seem to execute a warlike dance, analogous to the Pyrrhic dance (Fig. 66).- In another pair one divines pugilists preparing to strike each other. A musician turns his back to the athletes and makes resound his lyre with four strings; thus he regulates the movements of three dancers. One of these has sprung into the air, very high above the ground; he is the leaper mentioned by Homer. The two others have not left the earth; the entire weight of their bodies rests on the right feet. In the other part of the band, two men allow to hang between them a long garland of foliage; then is a singular combat, that must be an imaginary fight, one of the figures of the Pyrrhic dance, between two warriors armed with long swords. Further on is a second player on the lyre and two water carriers, doubtless two women, bearing pitchers on their heads, in their hands is the garland. The instrument marks the cadence of their steps, and they march thus in procession toward the sanctuary where they will sprinkle the lustral water. Finally, in this part of the scene is a singular motive, that seen in that place is not surprising; near the player of the lyre are two animals facing each other, who devour a man girded with a sword. We s shall have occasion to return to that detail.

This singular caprice of the painter does not deprive the observer of the general sense of the scene; that represents some local assemblage, one of the religious festivals of Attica, or in one of the adjacent provinces. The gymnastic games were comprised in the programme of the solemnity. Men found pleasure in representing these combats. A couple of pugilists ornament

the neck of a pitcher, that seems to have come from the same workshops as the vases of the Dipylon.[1]

Note 1.p.182. Gazette Archaeologique. 1888. p. 180. and Plate 25. Louvre. Coll. A. 568.

Finally, a fragment of a great funerary vase offers in one of its bands the representation of a battle with the wounded, corpses being heaped or scattered over the ground. (Fig. 67). One will note the variety of the arms, helmets with long crests, and shields, some of which are rectangular and the others are oval with deep notches, the bow of bent wood. On the lower band is a file of warriors, on the march.

We believe that we have drawn up a nearly complete list of the themes, that formed the repertory of the ceramic painter, from the moment when the figure of the animal and soon afterwards that of the man had appeared on the ground of the vase. When the potter was thus emancipated, he did not use the brush alone to vary the appearance of his works; he also decorated them by images modeled in relief. Thus he took pleasure in placing on the flat or slightly rounded covers of certain large and low articles, such as boxes and those of a sort of tureen, groups od three or four little horses (Fig. 68). Also sometimes to ornament the cover and form the handle, he has placed a second vase of small dimensions and elongated form, instead of horses (Fig. 44). Here a serpent is modeled in relief and extends along the ear; its head rests on the top of the handles (Fig. 69). There the serpent undulates around the orifice.[1] When he takes this method, the potter imitates products, that are derived from another technics. These overlays are better suited to metal than to clay, or at least they are more naturally derived from metal. Soldering or a few rivets suffice to connect them to the body of a vase of gold or of bronze; such were found at Mycenae. Clay does not refuse to lend itself to arrangements of this kind; but it does not suggest them to the workman. The junction that he makes with slip between the surface or the ears of the vase and the applied objects modeled in high relief is never very solid.

In following the art of the ceramist in its evolution, we have reached works in which the technical skill displayed by the workman, the diversity of the procedures employed and of the scene represented, shows a rapid and decisive advance; one

feels the coming of the hour when the painter and his patrons, weary of the monotonous and labored play of lines, will be more interested in the image of man, whose attitudes and movements change with the situations in which circumstances place him, and with those where poetic fable treats him, the ideal transcription of real life. Yet we have not believed it necessary to separate the two kinds of vases that we have described. We have divided them into several groups; but all those groups have appeared to us to form only the same family, in spite of the peculiarities by which each of them is distinguished, and which are defined by the importance retained by linear ornament and by the persistence with which the same motives are repeated, from the paintings whose authors do not seem to have suspected the existence of organized beings and those that numerous persons people and animate by their life. Not only on those vases that one can regard as most advanced are always the fret and the other motives of the same kind, that furnish the spaces in which are these figures; but also these motives, entire or separated in parts, are scattered between the persons as if by chance, in the field that they encumber. The habit is so successful, that they end by employing in the same fashion the figures of animals, that the first succeeded in introducing as decorative elements in geometrical ornamentation. One understands the presence of fishes, and even that of aquatic birds in the scenes of naval battles; but what places those birds in the representation of funerals, where they are beneath the catafalque and between the legs of the horses (Fig. 6)? It is even more strange to see fishes under the bellies of the two horses, that a man holds by the halter (Fig. 48). Such practices define the character of this art in which the image of the living being always remains in some fashion subordinated to that geometrical element which preceded it.

What were the origins of this geometrical style? How and why was it substituted for the Mycenaean style? What was the secret of its triumph and of the long empire that it exercised?

It is impossible to see in the geometrical style a simple transformation of the Mycenaean style. How can one admit, that the ceramic painter at a given moment suddenly became indifferent to the beauty of life? From this spectacle of the organic world in which he had begun to interest himself, did he sudden-

suddenly turn away his eyes so as to further be pleased only by cold abstractions? He was accustomed to require especially from linear design broad bands, that extended like so many belts around the foot and body of the vase. That was usually decorated on only its upper part. When the workman did not place there the supple scrolls of his favorite spirals, he arranged on this field the shells and fishes that inhabited the waters of the Grecian seas, the algae that covered the rocks, the leaves and flowers of the country of Argolis, the animals in the midst of which he lived, and finally the man in the diversity of his occupations. Sometimes even with a sort of carelessness, he spread over all the surfaces left for him by the potter the flexible stems of the plant or the long rounded arms of the octopus and the nautilus. One scarcely has to believe that this artist of himself renounced those free charms to create this formal style, that with inflexible rigor subdivides into compartments the entire extent at its disposal, which it fills beyond measure, the style extends and is stiffened by the right line, which it causes to dominate everywhere, admitting the curved line only in a single form, that of the isolated circle or joined by tangents.[1]

Note 1.p.185. These differences the Mycenaean and the geometrical decoration have been well indicated by K. Masner in the historical summary, that he placed at the head of his description of the ceramic museum in Vienna. (Die Sammlung antiker Vasen und Terracotten in K. K. oesterreichen Museum. Vienna. 1892).

In certain respects, there is an advance from Mycenaean ceramics to that succeeding it. In the latter is more developed order and rhythm; composition is there restricted to a symmetry that may seem excessive, but however where the work of reflection makes itself felt better than in the works of the earlier school. Yet there was a real loss when geometrical ornamentation was substituted everywhere for its predecessor. By the narrow system that it had adopted, are deprived itself of the resources supplied to the ornamentist by the imitation of the living form. This is an entire change of method, and a change too radical for one to see in it an organic evolution, the result of the effort of a mind in search of new means of expression. How was it produced?

As it has been believed, is geometrical design "the first re-velation of the artistic sentiment, the first movement made by art after its awakening?"[2] It is permissible to doubt this. T This mode of design is abstract, at assumes a certain degree of reflection. Before combining lines, like a child, man feels t the temptation to attempt to copy what he sees. The true type of the primitive draftsman i that young man, as related by t the ancients, who undertook to fix on a wall with a coal the shadow cast by the profile of his betrothed' it is the youth-ful Giotto doing likewise for the outline of an ass. When they traced those sketches, the Greek and the Florentine were near er that first designer than was the artist of the Dipylon, when he arranged the complex equipment of his chevrons, checkers a and frets. What proves this and confirms the deductions that c can be derived from psychology, that drawing of the quaternary period, on those bones of the reindeer decorated by engravings, that are the most ancient monuments of sculpture, one finds n trace of linear decoration; on the contrary, what is found th-ere in various attitudes is the figure of the concrete being, men, animals and plants.[1] Yet if not the first in date, linear decoration was born soon after imitative drawing by a sort of spontaneous generation among all peoples, from the first steps that they made in the paths of civilization. Nature even sugg-ested the idea and supplied the elements. Certain rudimentary industries everywhere aroused the development and ensured its progress by the materials employed and by the procedures used to utilize them.

Note 2.p.185. Fröhner. La Verrerie antique. Description de la collection Charvet. p. 71.

Note 1.p.188. Conze has seen this very well, who in a recent memoir has studied anew the origins of the general style. (Ue-ber den Ursprung der bildenden Kunst, in the Sitzungsberichte of Academy at Berlin, Feb. 11, 1897).

We have so far taken our examples only from paintings on va-ses; but clay cannot be the sole material to which ornamentat-ion was applied, and not even the ceramist invented it. Neith-er the geometrical style, nor any of the styles that we have to study was derived from clay.

There are materials, like metal or wood, that oppose a cert-ain resistance to the tool and force, or rather induce the hand

to make certain movements rather than certain others. Doubtless in even this case one cannot state what was the material, that created the style. If it was thus, there was for each material only one system of decoration, which remained always nearly similar in the most different places and peoples. Now matters do not so proceed. A piece of Mycenaean jewelry is distinguished at first sight from a work of the 5 th century B. C or from one of the Renaissance. Yet when compared, all products of the arts of met.l present certain analogies. The designs are not all traced alike; but they have the same accent and a sort of family air. It is that at Mycenae, Athens and Florence, to cause ornaments in relief to project or to sink them, it was necessary to give the same blow to the hammer and chisel, to direct in the same fashion the point of the graver.

Clay does not have its preferences and requirements like wood or metal. Of all materials it is the most docile, or as better said, the most passive. In the moist state, it lends itself with absolute indifference to receive all forms and all impressions. When the fire has hardened it, it offers surfaces that are like blank pages on which the brush can apply the motives of the most different styles at the pleasure of the imagination. It is then elsewhere, in the industries that employ materials suggesting forms, that it is proper to seek the origin of the motives which ceramics has preserved. Now there are two elementary industries, whose procedures appear to furnish a plausible explanation of the character of the designs composing the repertory of the ornamentist, whose works we have described. Those industries are those of the weaver and of the basket-maker, as also that of the workman who raises or engraves metal to decorate its surface.

It suffices to have seen a trade at work, to have seen the shuttle slide within the warp, to understand that rectilinear motives are those best suited to the textile industry, those obtained without difficulty by the crossing of threads of many colors. Such are those that decorate the long robe in which is clothed the woman, that appears to be represented by a curious statuette discovered in 1771 by peasants in a tumulus on the right bank of the Danube (Fig. 70). In this respect has been recalled the "bassaris" that forms the national costume of the nomads of Thrace. What forms the particular interest of

this rude image is, that one sees there better than in the paintings of vases, what is given by the work of the trade among people little advanced, but which already hold to a certain search for decoration. The motives that here ornament the fabric are black and white squares, which alternate with chevrons and wolves' teeth. As for the firoles preserved on the back, those are metal pendants attached by little cords to the wide girdle around the waist. The weaver is obliged to be very ingenious, to struggle in a way with his apparatus in order to obtain curved motives; he only attains this late by means of already wise combinations. When the weaver made his apprenticeship, he already had before him models, that after his first attempts must have furnished him with the simplest motives. Before knowing how to carry on the trade of weaving, there had been made mats and baskets. There again the right or acute angles were made by manual skill that created the plait. The parallel bars and their intersections, the chevrons and lozenges arise of themselves under the fingers of the basket-maker, when he interweaves the stems of rushes or willows of different colors. Now what dominates in the ornamentation of our vases is the straight line an the varied combinations that it produces. It is then probable that the principal elements of this decoration were borrowed from designs, that the ceramist had under his eyes, scattered over the mats and rugs that covered the floor of his tent or his hut, on the baskets used by the women, and on the fabrics with which both sexes were clothed.[1]

Note 1.p.188. Certain of these ornaments may be from embroidery; but the taste did not change, whether the women used the needle or the shuttle. The designs that their needles added to the clothing were the same that they inserted in the cloth when they made hangings and rugs. The influence of the basket-maker must have exerted on the potter has been especially studied by Kekule. (Arch. Anzeiger, in Jahrb. 1890. p. 106-107). On the order in which must have appeared the various elements of linear decoration, see Milchhofer, Anfänge der Kunst. Note of p. 50.

On the other hand, on our vases among these rectangular ornaments that occupy most space, one sees the circle appear. It only plays a secondary part there; but i no less contributes to give to the style of the painters of the Difylon its peculiar stamp. Now neither from the mat, nor from the varie ies of the

fabric of wool or of linen came the circle. To explain the part derived from it, by the painter, is is necessary to refer to a different technics, to that of the industry of bone or of metal, that early played a considerable part in the life of the tribes by which were peopled Greece and the adjacent countries; these industries did not need a long time to find the motives, that they applied to the decoration of their works. The choice of those motives was dictated to them by the properties of the material and by the use of the tool. Thus was formed a mode of ornamentation, which has characteristics sufficiently marked for one to recognize it in even the borrowings made from it by other trades.

This style adopts and utilizes most of these motives composed of rectilinear elements, that form the repertory of the basket-maker and weaver; there is no material on which the straight line cannot be inscribed; but in the decoration of cylinders and plaques of bone or of ivory, as in that of vases or other utensils of metal, besides rays or parallel bands, chevrons and frets, is seen to appear another element, to which the entirety must present an appearance different from that of the mat or rug. In the working of metal, the circle originates of itself in the course of the execution of the decoration. If it concerns repoussee work, one of the first ideas presenting itself to the mind of the artisan is to arrange on the external surface of the object bosses or little rounds, whose projection recalls the round of the breasts of woman; not a circle g gives in plan the contour of this boss. If one seeks the principle of the decoration in the use of overlays placed on the ground, the metal wire wound like a ball, gives spirals whose number will vary with the dimensions of the space to be filled. (Vignette at the end of Chapter V). Finally, if from engraving is demanded the whole or the complement of the decoration, in practice is more expeditious to scatter over the field designs in elegant symmetry, than to swing thereon one poin of the compasses, as done on the ivory plaques collected at Spata;[1] thus are obtained concentric circles or segments of circles, that give rise to very varied combinations; to deepen them the graver follows the slight lines indicated by the tool. Made supple and certain by long practice, the fingers of the workmen must further very often do without the compasses. I have seen

in the bazaar of the tailors at Cairo a designer with chalk fr freely trace on pieces of cloth to be embroidered then by the needle, curves of quite mathematical precision, although drawn freehand.

Note 1.p.189. Bull. de corr. hell. 1878. p. 207:- "The more numerous examples of rectagular plaques are decorated by circles; they are traced with the compasses.

Thus three, the industries of braiding, fabrics and metal, then sufficed to supply the ceramic painter with nearly all the motives, that served him for decorating those vases in which t the ornament remains purely linear. To imitate the form of the plant, and especially to copy those of the animal and of the man is always a more difficult matter than to draw squares, lozenges anf circles. To copy life with the diversity of its types, each of which has its own expression, requires a very different effort of observation and of reflection. Where the arts of design are in their infancy, that effor is reserved f for those branches in which it seems imposed as necessary, by reason of the special role of certain objects. One is restricted for goldsmith's work that carries jewels, arms and cups for princes, or for sculpture that models the images of the gods; but for pottery that must be fabricated and furnished in great quantities, it was natural to adhere to the kind of decoration, that without putting the workmen to the trouble of invention, best len itself to the exigencies of rapid execution.[1] Thus for a very long time are explained the motives peculiar to the geometrical style, here and there relieved and e enhanced by some figures of birds and of quadrupeds, that formed all the cost of the decoration of clay vases. The ceramist found those motives elaborated in other technics; to profit by them, there sufficed him a sort of almost mechanical skill, that he acquired by practice.

Note 1.p.190. A. Riegel. Stilfragen. p. 30.

Yet there came a moment, when in a society that became richer and more refined, it was no longer possible for the painter to content himself with the arrangements furnished by purely linear decoration; men required him to inclose in these ornaments scenes taken from the lives of his contemporaries; but even t then in this new phase of the development of his style, a painter still felt the influences of the models by which he was

first inspired. Perhaps the figures that appear on the vases of the Dipylon were originally imitated from images, that about the same time the shuttle of the weaver had scattered in t the warp of fabrics of luxury, the primitive weaving only admitting rectilinear designs. What has suggested to me these conjectures are the ancient Peruvian fabrics. I see there animals and men whose type has suffered the same sort of deformation as on Attic vases, has been geometrized in the same fashion, if we may be permitted that barbarism. Thus the cat has taken a square head and a lozenge tail (Fig. 71); for men, in the drawing of the body and members are eveeywhere straight lines and acute angles (Fig. 72). The tombs of the Ceramicos of Athens have not preserved fabrics for us; but the cloths that enveloped the b bodies of the Eupatrids in the richest of those sepulchres were executed in a manner, that must have very strongly resembled that used by the subjects of the Incas, and have given rise to nearly the same arrangements. In the decoration of the vases that we have reproduced, there are no motives that do not find their application in the practices of two or three industries, the most indispensable of all, the rush-work, the weaving of wool and linen, the working of bone and of metal. It suffices then to render a reason for the peculiarities by which is defined the style of these vases, that the tribes that fashioned t them possessed the industries mentioned. On the other hand, if those tribes had artists capable of executing works such as the cups of Vaphio and the most beautiful of the intaglios accompanying them, the ornamentation of their ceramics did not present with its air of variety the character of poverty and of monotony, that we have mentioned; one will find there the trace of t that sentiment of life, that forms the originality of Mycenaean art. That sentiment is lacking; one is thus forced to admit t that the potters, who fabricated the vases with purely linear decoration were not the direct continuators of the potters of Mycenae and of Ialysos. This hypothesis does not remove all difficulties; but however it gives the sole plausible explanation of the contrast that strikes the historian. He knows himself to be henceforth in the presence of an art, that did not have the same origin as its predecessor, which was born in different surroundings, and which was imported into Greece by other tribes. It is to be sought among the tribes, that were

reputed to have concurred in forming the Greek nation, whether to some of them is there some reason to attribute that role of that initiative.

According to the idea that we have formed for ourselves of the history of the Grecian world, a great disturbance was produced about the 11 th century in all the southern part of the Hellenic peninsula. New inhabitants in the most fertile and most populous districts were substituted for the ancient ones, who were forced to emigrate toward the islands of the Egean sea and the coasts of Asia Minora If it be proved that a change of taste was caused in Greece in the arts of design at abouu that time, that a new style replaced that which had reigned as master during the course of the preceding senturies, this conclusion is imposed:- that this taste and this style must have been introduced into Greece by the rude and warlike tribes, which tradition groups under the generic name of Dorians.

These invaders are not pursued by Grecian historians beyond the mass of Mt. Pindus, which they must have reached by slipping among the long chains, that detach themselves from the central nucleus of the Alps, and which cover with their ramifications the ertire eastern peninsula of Europe, but in the silence of history there remains one resource, which is to apply to the monuments themselves to ask if they cannot aid us in going higher into the obscure past of those tribes, and to throw some light upon their origins and their ethnic affinities.

It is a fact that the archaeological researches of the last years have placed beyond doubt; in the valley of the Danube and in all southern Europe as well as on both slopes of the Alps, from the centre of Italy to the basins of the Rhine and the Rhone, one finds scattered everywhere in the tombs and among the ruins of very old market townr, the works of an industry, whose style recalls that of Grecian ceramics with linear decoration. The analogies are those that cannot be the result of a simple accident. In those monuments, whether of stone, of clay or metal, one finds nearly all the motives whose use characterizes those of the works of that ceramics, that can by good right pass for the most ancient.

The comparison would convince little, were it based only on the motives detached from the context and arbitraily isolated. To regard them thus, there would be little that one succeeds

in finding in the works of other peoples, some of whom do not appear to have been able at that time to influence Greece by their example, while others are separated from it by the entire breadth of the ocean. It is that it would be easy to prove, either by referring to the rare remains of the products of Assyrian and Phoenician ceramics,[1] that we have been able to discover, or by presenting some specimens of Mexican, Peruvian or Kabyle ceramics.[2] The true resemblance, that attesting the same origin, a relation of connection and dependance, is indeed much less in the similarity of the motives taken separately, thanthat of the order according to which they are grouped, in what way may be termed the syntax of ornament.

Note 1.p.193. Histoire de l'Art. Vol. II. Figs 273-279; Vol. III. Figs. 478, 479.

Note 2.p.193. Being unable to institute this comparison here, we refer to the labors of M. Holmes, who is the specialist most competent for the study of Mexican ceramics. He is curator of a special department of ceramics at the National Museum in Washington. See the fourth annual report of the bureau of ethnology (Washington. 1886), the Memoir entitled Origin and development of form and ornament in ceramic art, particularly pages 459 and 484, and in the same volume another study; Pottery of the ancient pueblos.

The industry that we have in view, that it has been proposed to name Pelasgian, Celtic, Celto-Illyrian, persisted in Italy until there made itself felt on the coasts of that country the influence of Phoenicia, and particularly that of Greece. Without changing scarcely anything in its practices, it maintained itself in central and southern Europe until the Roman conquest. Not types absolutely similar, should one expect to s succeed in finding, when he makes out the inventory of the multiple work of the tribes, that were dispersed over such great areas, when he compares objects between which there may be a d distance of several centuries. learned men that have made this kind of antiquities their special study find differences therein, that have allowed them to divide those monuments into several groups, each of which is defined by certain traits peculiar to it. We cannot make that distinction here. The common characters that give to all these works an air of relationship are sufficiently marked, that one can regard that primitive civ-

civilization as forming an homogeneous entirety, at least from the point of view of art. In these conditions, we do not fear to urge in support of the theses, that we propose to support, proofs or indications , if it be preferred, that we have collected nearly everywhere in the different provinces of the realm of geometrical decoration. The safe rule that we shall impose on ourselves is, that our observations will only be based on works in which this style, still near its origins, has retained all its characters, so to speak. By this means we leave aside for Greece the most advanced vases of the Dipylon, with t the personages there represented, and for the barbarians as a Greek would have said, the "situles" of Styria and of the valley of the Po, or a chisel that already did not lack skill in modeling scenes of games and of sacrifices, hunting and war.[1]

Note 1.p.184. One will find reduced but faithful figures of most of the representations that decorate those bronze vessels in the work of M.M. Al. Bertrand and Solomon Reinach; Les Celtes dans les vallees du Po et du Danube. 1894.

In the monuments that we are going to seek thus outside the frontiers of Greece, we shall again find the arrangements and characters, that have seemed to us to form the originality of the vases that we have just studied. The same instinct for rhythm, which recalls that of the architecture; the same habit of dividing the field into compartments, in each of which the decorator multiplies the ornaments, desiring to leave no voids, the same very marked predilection for the straight line. The straight line and its combinations furnish nearly all the secondary motives, even where the principal lines of the ornamentation are and can be only circles. Particularly from the industry of metal shall we borrow our examples, for in the different countries from which we take them, ceramics is very much behind metallurgy. Men were long satisfied there with a pottery, whose very elementary decoration comprises only some rudely oncised lines. To meet with vases on which the ornament was applied with the brush, it is necessary to come down to about the middle of the 5 th century B.C., and it would be strange to take monuments of so late an epoch for seeking there some light on the origin of a style that flourished much earlier in Greece. One has the right to demand this service only from works, that may be presumed more ancient than those occupying us, or that

can at least be contemporaneous with them. The bronzes will t then almost alone offer us terms of comparison. Now in what remains of a number of pieces, cups, shields and plates intended to serve as insignia or ornaments, that take the circular form. For example, such are two disks of bronze found in Italy among the Equez.[1] Concerning the shield of Achilles, we have r reproduced the larger one of them (Fig. 17). These disks are only decorated on their faces exposed to view. Whatever the purpose may have been, the extreme care with which the decoration was executed indicates objects of price. The workmen made use of all procedures to which metal lends itself, of repoussee work, as well as engraving with the point and the dotted line. To the hammer is due the relief of the little bosses, that are separately arranged and project from the ground, a fine point traced all other designs. Those nearly touch; one feels here t the same horror of the void as on the vases of the Dipylon.

Note 1.p.185. Thisi disks hove been published with o learned commentary by Gion Corlo Conestobile in o memoir entitled:- Uovro due dischi in bonnzo-itolici del Museo di Perugio e soovro l'orte ornomentole primitivo in Itolio e in oltre porti di Europo, recherche orchoeologiche comporotive. Turin 1874. ((Extract from Memorie de l'Acodemie be Turin. Series II. Vol. 28). Also see the bronze disks from Mursio. (Notizie degli scovi. 1880. Plote II). It is the some decoration.

Among the motives composing this decoration, we find some not previously known to us. The concentric circles circumscribing the bands on which these motives are distributed correspond to the bands, that like belts divide the height of Greek vases into unequal zones. The very fine lines that extend here in the vicinity of the border are found on the feet of the vases. (Fig. 42). As on those vases, here not only the principal lines of the decoration furnish the circle reduced to a very small diameter; there are double or triple rings, that in places are scattered in two of the circular crowns. The curved line is here required only by the circle. Nowhere is perceived the spiral or any of its derivatives, not even that sinuous line, whose bends imitate the undulations of the sea waves. What forms the central motive is no the rosette issuing from the flower; it is a sort of star formed by the triangles open at one side and with opposed apexes. All being small with adjacent bases,

these same give for one of the bands the running motive called wolf's teeth, and in another nearer the border extends an ornament with the same principle, called the chevron, with its symmetrical breaks. finally, on the larger of the two disks, one has the fret or at least a sketch of the fret in the growing state. The motive consists of two angles, whose horizontal arms are directed in opposite directions; join those arms by a line and you will have the classical fret.

Here is a last coincidence, and it is not the leas singular. The sole motive that recalls here the existence of the organic world is that, which in Greece also appears sooner on vases with geometrical decoration; it is the bird, that one recognizes by the length of its flexible neck and that of its beak, as the inhabitant of the marsh and the shore. A frieze made of these birds surrounds the boss, that forms the middle of the disk.

These types of webfeet and waders seem to have had a singular attraction for the primitive artist, both of central Europe and of Greece and Italy. To the first it appeared during the summer migration; to the second in the entire duration of the mild winters of the sou h. There settled in multitudes on the ponds the swans, geese and ducks, storks and cranes. In our country, where lead awaits in the morning the bird of passage, nothing can give an idea of those prodigious flights, that filled the entire district with the noise of their wings. I remember having also seen in Asia Minor in the marshes near Nicea and also near Samsoun actual armies of geese; it was in vain that I endeavored to approach within gunshot, the bird had learned mistrust. In high antiquity, man could see them nearer, disporting themselves, swimming, diving and passing near in great flocks, at the tops of the reeds and tamarisks. One believes himself to feel the echo of the impression, that this sight made on the mind, in a comparison of Homer and in the imitation of it, that Virgil has given. (Latin).[1]

Note 1.p.196. Homer. Iliod. II. 459. Virgil. Georgica. I. 360-3

The two disks are not isolated objects whose ornamentation presen s an exceptional character. In all central Italy, this system of ornamentation was not solely applied to metals; one finds it on the clay vases with incised designs, enclosed within the so-called pit graves, that are the oldest type of Italic and Etruscan tomb.[1] No if one could be tempted to see in the

bronze objects imported articles, it would not be the same for those potteries, that have come from the cemeteries in thousands; the were necessarily fabricated at the place. to show the identity of the style, it suffices to present here some specimens of this manufacture, some taken from the cemetery of Villanova in the vicinity of Bologna (Figs. 73, 77), and the others from the necropolisees of Orvieto and of Chiusi, in Etruria. (Figs. 74, 75, 76). One will recognize the motives that we have found in Greece and again seen on the metal disks, circles, frets in their varieties, chevrons, incomplete triangles set within each other, lozenges, and the division into panels with centre occupied by a fylfot cross. On those clay vessels as on the bronze plates, scarcely anything arouses the idea of life; on only one appears the image of man, it is so well concealed among the flourishes of the linear decoration, that it does not modify the general appearance of the entirety (Fig. 77). The outside of that bowl is entirely covered by ornaments, that are arranged in concentric zones, but without their being limited by circles traced with the point. Here are arranged in a row of aquatic birds, met with so many times; but nearer the border is the human figure imitated in an entirely schematic manner, that one believes that he can recognize in the little details, that all have their heads turned toward the centre. With regard to the actual dimensions, this figure has been more reduced than that of the bird, and the form has been more changed; yet it seems that there is a dancing chorus, analogous to that presented to us on the vases of the Dipylon (Fig. 50). Like those, the bowl of Villanova dates from the time when the geometrical style tends to lessen the rigor of its system.

Note 1.p.189. For the description of those tombs and their equipment, see Chapters 2 and 3 of Jules Martha's L'Art etrusque. Paris. Didot. 1889.

We could multiply these examples; but those that we have selected suffice to justify the comparison. What they demonstrate is, that there was a time in Italy during which among the peoples, who appear to have maintained very few relations with the outside, the workmen constantly applied a system of ornamentation, which does not sensibly differ from that, which we have studied in the monuments of one of the periods of the development of Gracian ceramics. In both is the same principle; those are

the same elements that are grouped in the same fashion by the designer. Like the vases of the islandsor of Athens to which we compare them, the potteries and bronzes furnished by the most ancient cemeteries of Umbria and of Etruria are not dated; no inscriptions, no more than on those of the Egean sea. However, by an entire series of remarks and deductions, the learned have labored to restore the history of primitive Italy and have arrived at an approximate chronology; according to them this would be between the beginning of the 10 th and the end of the 8 th centuries, that the still rudimentary civilization flourished, already very distant from barbarism, whose relics have been preserved by the cemeteries from which we have borrowed some t things. Now our researches lead us for Greece to a result entirely similar; during the course of some three centuries the gemoetrical style had succeeded the Mycenaean style, and that had accomplished the evolution which we have followed to its end.

We know that the Dorians and the other warlike bands, whose intervention so profoundly modified the condition of Greece, descended from the mountains of Macedonia. On the other hand, one believes that he follows the trace from the foot of the Rhetic Alps to the centre of the peninsula, of the tribes t that have peopled Italy, and which under various names have finally played the first part there.

But in regard to both, these facts have suggested a very probable conjecture; we shall have to seek at the north of the Balkans and of the Alps the origins of the first country of the geometrical style. This system of decoration the fathers of the Dorians, of the Umbrians, Sabellians and Etruscans, practised in those vast regions of central Europe, that they inhabited side by side before passing the barrier of the lofty chains bordering the plateaux, of spreading themselves in the basin of the Mediterranean; they brought it with them in their b baggage, if one may so speak. If this be so, nothing is more natural than the resemblances that have struck us. Whether they were directed toward the southeast or the southwest, these emigrants had no time to lose on the journey, the habits and tastes, that they had acquired in the course of a slow and laborious apprenticeship. However seductive it may be, this hypothesis would fall of itself if in the region itself, where we in-

incline to seek the cradle of the geometrical style, there did not remain some monuments. Is that the case? The response to that question will be furnished to us by the monuments of the age of bronze or of the first age of iron, that from Hungary to France, from Tyrol to Scandinavia, have been taken from the tombs of the peoples, that Greco-Latin civilization scarcely reached before the beginning of our era.

To make a comparison of objects having like forms and an analagous purpose, here are two bronze disks, one of which comes from Austria (Fig. 78) and the other from Sweden (Fig. 79).

In general both are identical with that of the plaques of Alba Fucensis. The same little bosses that project from a decoration executed with the graver. The motives are those that we have already noticed, the fret, though incomplete and in t the state of a sketch, the triangles with open bases serving to complete a central motive, or indeed more reduced and filling an entire band with the notches of their points, the rings formed by circles of small diameter with a point at the centre, bands of parallel lines, etc. (Fig. 78). On the disk in Vienna nothing recalls life; but a row of marsh birds with some bosses raised with the hammer make the sole ornamentation of the disk in Stockholm (Fig. 79).

In Greece the painter loved to connect those rounds by tangent curves, often with central points, that he scattered over the body and neck of his vases (Figs. 38, 39). We have not found this motive in monuments from Italian sources; but one sees it reappear on the bronze belts, that have been taken from the t tombs of the celebrated cemetery of Hallstadt in the province of Salzburg in Austria (Fig. 80).[1] This is particularly one of the ornaments preferred by the workman that fashioned the belt plates of the same metal, that have been collected in Denmark and Sweden (Fig. 81).[2] The scrolls that pleased that artisan r recall those of the Mycenaean spiral.

Note 1.p.202. Von Sacken. Das Grabfeld von Hallstadt in Oberoestreich und dessen Alterthümer mit XXVI Tafeln. Vienna. 1868. Besides the example cited, Pl. IX, Figs. 2, 7, 8, and Fig. 4 on Plate X.

Note 2.p.202. O. Montelius. Les temps prehistoriques en Suede et dans les autres pays scandinaves, a work translated by S. Reinach, with map, 20 plas containing 120 figs. and 429 figs c

in the text. Ernest Leroux. 1895. Besides the object reproduced here, see Pl. VIII, Figs. 8, 9, 10, and Figs. 85, 87 in the text.

One remembers that the potters of the Dipylon loved to place on the covers of their vases horses or birds modeled in the r round (Fig. 68). Examples of that arrangement are also found in central Europe.[1] Here is a bronze pail from Carinthia, where images of horses ornament the edge of the vessel (Fig. 82).

Note 1.p.203. Kunsthistorischer Atlas, herausgegeben von der K. K. Zentral-commission zur Erforderung und Erhaltung der Kunst und historischer Denkmale, etc. Part I. Collection of illustrations of prehistoric and early historical finds from the lands of the Austrian monarchy. Edited by Dr. Much; 100 pls. and numerous figures in the text. Vienna. 1889.

The study of the pieces composing this series then leaves a very clear impression; the principle of the decoration is the same as that in Greece and Italy; the same elements are grouped there in the same spirit.

It seems impossible that men have not been struck by the resemblances; they must have also noted the differences. Among the monuments that have been presented as specimens of linear decoration from Italy, central and southern Europe, is no one where this decoration has the same appearance of coherence as on the Greek vases of the same sort. In both, the elements are the same; but the entireties do not have the same aspect, the same look.

The hypothesis that we have presented gives the reason for that difference. The motives that we have enumerated, constituted in the course of the period preceding the dispersion, the repertory of the rustic ornamentist, among all the semi-barbarians that inhabited the valley of the Danube. Those of the peoples that passed neither the Balkans nor the Alps remained in during long centuries a nearly the point where they were before the separation; but it was quite otherwise with the group, whose dash carried them to the shores of the Egean sea. The immigrants there found established the practice of an industry and of an art much more advanced, whose monuments they found everywhere, either in the form of richly decorated edifices, or of works of sculpture, of jewelry and of ceramics preserved in the treasuries of princes and in the tombs that they pillaged. They saw and admired; the impressions so received could not fail to

incite them to develop and perfect the mode of ornamentation familiar to them.

On the other hand, skilful artisans were not lacking in Greece; those that had previously worked for the Achaian kings had left behind them heirs of their processes and their secrets. Deprived of their ancient patrons, these workmen had in interest in ensuring for themselves new ones, in fabricating objects with a fashion in accord with the taste of the powerful men of the time. To succeed in this, they only had to inspire themselves by what they saw. The motives of linear decoration ornamented the arms of the warriors of the North, the jewels by which their wives were decorated, the clothing that they wore, and the fastenings that served to fix it on the body; in all that costume and equipment of the new masters of Greece was where the ceramist, a pupil of the old workshops, would have sought suggestions and ideas.

What must have lent most to that sort of borrowings was metal. We know neither the sword, helmet, nor shield of the Dorian soldier; but it is otherwise with the brooch. That only appeared at Mycenae very late, in the tombs of the lower city, which a are perhaps of the time when the Dorians had already set foot in the Peleponnessus.[1] On the contrary, those clasps are frequently found in the tombs that contain vases of the geometrical style, and they have also been collected in the most ancient layers of rubbish, which at Dodona and Olympia were formed around the temples by the accumulation of the offerings.[2] The p brooch thus carries its date, at least approximate. It would be about the 10 th century that the custom began to extend among the Greeks, and one has based thereon th search for the type of ornamentation that the metal received from the artisan among the Dorians and related tribes. To justify this assertion, it suffices to show here a brooch that came from Olympia (Fig. 33). On both faces of the wide plate is nothing but motives of the geometrical style, panels formed by parellel bands, points, chevrons and wolves' teeth. In the central part is a bird, like those found so often on the vases, and something that vaguely resembles lanceolate leaves. The same kind of decoration is on bronze bands collected at Olympia and Dodona, bands that served as facings of chariots, coffers, seats and other furniture of wood.[1] One of the ornaments that most frequently fills the field

of those bands are concentric circles connected by tangents, and between two rows of chavrons (Fig. 34). Elsewhere it is the plait, where the eyes of the guilloche are filled by bosses with slight projection (Fig. 39).

Note 1.p.204. Histoire de l'Art. Vol. VI. p. 590, 990.

Note 2.p.204. Furtwängler. Die Bronzefunde aus Olympia. p. 36-38.

Note 1.p.205. The same. p. 10, 11.

The sedentary artisan, fixed in the ancient cities of European Greece and the islands, then found in those works in metal the models tha it was easy to imitate, while one brought into Greece with the invaders could not avoid suffering the influence of the models, that were offered him by the legacy of the past, what remained from Mycenaean civilization. From this collaboration of the conquerors and the vanquished, of the tribes from the North and the ancient inhabitants of the Hellenic peninsula was born the new style, which came to replace the Mycenaean style at the moment when it already betrayed fatigue and exhaustion, on the verge of the shock that should overthrow so thoroughly the society where it had flourished.

The elements utilized by this new style are found among other peoples; but about the 10 th and 9 th centuries in Greece, there was derived from them quite a different role, from that made by those who had cultivated elsewhere the same sort of design; they knew how to assign to each of these elements the place best suited to it, to establish a close connection between them all, and to group them according to the laws of symmetry and rhythm. In Greece and in Greece alone, from these motives that appeared elsewhere isolated and scattered, the artist had the talent to compose a system, all parts of which are in harmony with the others, and where the detail is subordinated to the effect of the whole. Linear decoration is a human phenomenon; one finds its traces everywhere; but nowhere of the same degree as in Greece, did it end in the formation of what can be termed a style, in the entire force of the term, a truly original style. This style is what the historian designates under the name of the geometrical style, when he follows Grecian art in its ample and rich development.

Linear combinations already held a great place in decoration in the course of the preceding period. It supplied to Mycenaean

ornamentation very varied motives; but they are there mingled with other elements. Mycenaean art, with the peculiarities of its original style had remained the art of some privileged kingdoms; it had its centres of production in the eastern part of the Hellenic peninsula and in some islands, such as Rhodes and Crete. In the rest of Greece a number of workshops were content with a very rudimentary geometrical ornamentation, which scarcely differed, except by the use of color, from that which forms the incised decoration of the oldest vases of the Troa and of Cyprus.[1] That ceramics, where the design applied by the brush is extremely simple, is found and has been studied in Caria,[2] at Amorgos and in the Cyclades,[3] at Cyprus,[4] in Attica and Boetia,[5] and even in Italy;[6] it has created painted vases to which it is difficult to assign a date, even by comparison; one does not know whether they are earlier or later than the vases with flat tones or the vases with lustrous tones from Mycenae and from Ialysos.

Note 1.p.206. Histoire de l'Art. Vol. VI. Figs. 445, 456; Vol. III, Fig. 485.

Note 2.p.206. The same. Vol. IV. p. 325-331.

Note 3.p.206. Dümmler. Reste vorgeschichte Bevölkerung auf d. Cycladen. (Athen. Mitt. Vol. XI. p. 15-46; and Beilage 2); he presents several vases with very simple linear decoration.

Note 4.p.206. Dümmler. Der kyprische geometrische Styl. (Athen. Mitt. Vol. XIII. p. 280-294). The geometrical style of Cyprus was a branch, which is no developed, of a s yle from which come the ornamentation of the Dipylon. It had been brought to Cyprus by the Arcadian immigrations; it remained more simple that that of Attica. The straight lin dominates there; it has a marked preference for rectangles and triangles; it also uses concentric circles but does not connect them by tangents; it employs to fill its bands neither the spiral nor the chevron. As specimens of this style, see Histoire de l'Art, Vol. III, Figs. 478 (found at Jerusalem, but perhaps of Cypriote origin), 479, 476, 487, 488, 491, 492, 494, 497, 498 etc.).

Note 5.p.206. On the primitive geometrical style of Attica, see Holleaux, Monuments et Memoirs. Vol. I. p. 35-40.

Note 6.p.206. We can merely mention here a workshop represented by numerous examples in the Museum of Naples and some specimens scattered in the other galleries of Europe. There has

been proposed for designating the name of old Apulion. These are characterized by entirely geometrical decoration and by forms frequently labored and eccentric. Winter represented four examples of them (Athen. Mitt., 1887, p. 240, 242), and asks whether they were not originally from Cyprus, a conjecture that appears very hazardous; there are forms not yet found in Cyprus. We believe rather in the local fabrication, that seems to have been prolonged very late.

Vases of that fabrication have been figured and described in de Hancarville, Cabinet Hamilton. I. Pl. 46, 113. De Laborde, Collection de Lemberg. II, Pl. 48, nos. 42, 43; Furtwängler, Catalogue des vases de Berlin, nos. 288 et seq.; Edw. Robinson, Catalogue of Greek, Etruscan and Roman vases. Boston . p.54; K. Masner, Die Sammlung antiker Vasen in K. K. Oesterreiches Museum, Nos. 38-41 and Pl. I; Furtwängler, Bronzefunde von Olympia, p. 8, 9; Pottier, Vases antiques du Louvre. Pls. 29-32.

Did the workmen that fashioned these common vases, only intended for local use, on the contact with the immigrants, take an active part in the elaboration of the new style, or did the chief role in that work belong to the continuators of the Mycenaean tradition? It is rare for a corporation of artisans to modify by itself the processes of execution, that have brought it vogue and fortune. One would then be led to suppose that t the geomethical style was rather formed in workshops, that were not those which transmitted from father to son the practices of the most competent industry.

What confirms this conjecture is, that the production of vases in the geometrical style commenced before there had ceased that of the vases of the Egean style. In many heaps of fragments at Tiryns, Mycenae and Menidi, the fourth style of Mycenaean pottery, which marked its decline, is not represented or very slightly so; remains of vases recalling those of the Dipylon are found mingled with those of Mycenaean vases of the third style. On the contrary, where as in the corridor of the Treasury of Atreus, there have been gathered many fragments of the fourth Mycenaean style, there is so to speak, no trace of vases with rectilinear geometrical decoration. Those were perhaps already made in the workshops at Argos, while the ancient industry completed its evolution at Mycenae.[1]

Note 1.p.207. Furtwängler and Loschke. Mykenischen Vasen.

p. xl. Dümmler also gives in reference to Cyprus good reasons for believing that the geometrical style was contemporaneous with the Mycenaean style, at least in certain parts of Greece. (Athen Mitt. Vol. XIII. p. 288-294).

If Mycenaean ceramics and that succeeding it thus continued side by side during a certain time, one terminating its career while the other developed its methods, one would not be surprised to discover vases, that by their forms and the style of t their decoration, adhere to both styles. These vases exist in different galleries; but the union of the two types makes itself felt better, where one can study it in an entire group of pottery, and there is reason for believing that this came from the same workshop. Such is the case for a series of pottery that came from the cemetery of Salamis.[1]

Note 1.p.208. Histoire de l'Art. Vol. VII. p. 51. Note 1.

These vases are all of small dimensions and recall Mycenaean pottery by their forms. There are a number of examples of the saddle vase (Fig. 36); but in the decoration is no trace of t that taste for the imitation of plants, marine animals and insects, that characterizes the true Mycenaean art. Nothing is here but a very simple linear decoration, bands of red and b brown that extend around the lower part of the body, and above in the vicinity of the neck are diagonal squares and semicircles with opposed convexities. Yet what is a memorial of the earlier ornamentation is the spiral, that the painter of the Dipylon scarcely employs, while he makes constant use of the fylfot cross and the fret, which is wanting at Salamis (Fig. 37). The motives are otherwise far from being so close as in the pottery of Ceramicos; a large part of the field remains void. This pottery of Salamis is at the same time of the impoverished Mycenaean and of the geometrical in the growing state.[2]

Note 2.p.208. At Eleusis, in a tomb buried at a great depth, have been gathered vases, that appeared to offer the same mixed character. (Ephemeris. 1889. p. 189-191). Recent discoveries made at Etna, according to me, furnished monuments of this kind.

There being given this more or less prolonged coexistence of the two ceramics, one expects to prove that certain forms and motives are common to them. The ceramics of the Dipylon, we h have shown, has no retained all the forms that its predecessor loved. As for the motives, some are found in both. Such are the

knobs that reproduce the projection of the bosom of the woman.[1] A sort of sinuous torus similar to a hairy caterpillar,[2] four leaves opposed in pairs,[3] concentric circles,[4] conjugate semicircles,[5] circles connected by tangents,[7] triangles,[8] lozenges,[9] checkers,[10] quadrilles,[10] the circle in which is inscribed a cross.[12]

Note 1.p.209. Mykenischen Vasen. Atlas. 22, 56.

Note 2.p.209. The same. 24, 133.

Note 3.p.209.The same. 226, 227, 239, 321.

Note 4.p.209. The same. 13, 145, 148.

Note 5.p.209. The same. 36, 315, 382, 393.

Note 6.p.209. The same. 173, 175, 241, 242, 370.

Note 7.p.209. The same. 31.

Note 8.p.209. The same. 160, 161, 183.

Note 9.p.209. The same. 246, 357.

Note 10.p.209.The same. 241.

Note 11.p.209.The same. 183.

Note 12.p.209. The same.166, 231, 232.

Did ceramics after the Dorian invasion borrow these motives from Mycenaean ceramics, or rather did these two ceramics derive them from a common source in the repertory of the primitive geometrical? the problem is not easy to solve, and one experiences the same embarrassment concerning the images that came to be inserted in the spaces of the linear decoration. Aquatic bi birds appear on the Mycenaean vases;[13] but they do not present themselves in the same conditions as on the bronzes of central Europe or Italy and on the vases of the Dipylon. There the birds are ranged in long files, where is always repeated a single outline. At Mycenae the bird is no better drawn; but it is isolated in a large field or indeed appears in pairs. Its attitude changes from one vase to another, and even in the extreme awkwardness of the sketch, one believes that he divines that the painter has had some care for the living model. That feeling of life is what will be wanting for a long time to the ceramist of the following age. When he will dare to attempt the human figure, he will present it in a more schematic and geometrical form than it was at Mycenae, and the themes of the painting in which it appears will further not be those that Mycenaean art loved to treat. One scarcely finds in the vases of the Dipylon that one scene can be regarded as a borrowing, that the

later ones made from their predecessors; this is that of the chase of the hare. (Fig. 64).[1]

Note 13.p.209. Mykenischen Vasen; 24, 63, 116, 186, 393, 397,40 Histoire de l'Art. Vol. VI. Figs. 467, 474, 489, 490, 494, 498.

Note 1.p.210. Histoire de l'Art. Vol. VI. Fig. 498.

The question of the relations of Mycenaean ceramics and of c ceramics with linear decoration still remains very obscure. For the latter industry, the period of attempts and experiments escapes us. If one collects its remains in the islands or at Athens, it evidences everywhere a taste, whose course is no longer to be sought. It is a style already formed; whatever its starting point, it must have spread very rapidly in the entire basin of the Egean sea.

This point of departure escapes us. All that we can prove is, that among the vases where the principles of the style have been applied with most vigor, a certain number of them came from the islands of Melos, Thera (Fig. 38) and of Rhodes. From the highest antiquity, Rhodes was one of the principal centres of the ceramic industry. Men have not forgotten what in eresting examples of Mycenaean pottery have been furnished by the cemetery of Ilaysos. That of Camisos has yielded but few Mycenaean vases; but the ceramics of the succeeding centuries is represented there by pieces, whose appearance is sufficiently peculiar, that one does not hesitate to see there the product of a local manufacture.[2] Mos of the vases of the geometrical style are distinguished by a species of decoration, whose use seems peculiar to the potters of Camiros. The designs are there detached as usual in brown on the red of clay, but the brush has the s same black lustre over all parts of the vase, where they did not desire to place ornaments. For example, here is a beautiful hydria of very careful execution (Fig. 39). Chevrons, lozenges and crosses ornament the neck and the top of the body, divided in panels. At the height of the shoulder, marsh birds form a frieze intersected only by the attachment of the ears. The p part of the black is greater in the cratera, which has especially this singular, in that one notes several times repeated t there between the concentric circles, an ornament in which one believes that recognizes the palm-tree, with the terminal group of its fresh palms and the falling of the withered palm leaves. (Fig. 90). The motive is already found on Mycenaean pottery.[1]

From the repertory of the workmen of the first age, it had passed into that of their successors.

Note 2.p.210. Jahrb. des d. arch. Institut. 1886. p. 134-137.

Note 1.p.211. Furtwängler & Löschke. Mykenischen Vasen. Text. p. 24, 45. Fig. 25.

There is another fabrication that cannot be passed over in silence; it is that of Beotia; it has been very fruitful. It is possible that it had its centre a Aulis, the same vases being found at Thebes, Tanagra, Ploion, and also elsewhere. The existence of the workshops of Aulis is attested by Pausanias.[1]

Note 1.p.212. Pausanias. IX. 19, 6.

Two periods have been distinguished in the development of the most ancient Beotian ceramics; one representing the primitive geometrical, and the other with its creations contemporaneous with the vases of the Dipylon.[2] the first is known principally by the excavations of Ptoion. "In the deepest of my trenches," says M. Holleaux, "I collected a great quantity of pottery pained with black varnish. These are for the most part cups, or great crateras and beakers of different forms. Their ornamentation is meagre and monotonous, little connected and quite scattered. Lines broken in zigzags, rows of lozenges, triangles and rectangles, voids filled or crossed, form the principal basis. Groups of concentric circles are placed in a row and frequently tangent, count in the number of motives most freely repeated. Here and there are found some representations of animals, water birds, more rarely quadrupeds. Never or scarcely ever appears the human figure.[3] Those vases must be the work of the local industry, for nowhere else has been found pottery exactly similar to this. On the other hand, this workshop did not suffer in any degree the inflaence of the Dipylon. Without speaking of scenes composed of several persons, that are never found in its products, one notices that no part is played here by the motives that characterize the style of the Dipylon, such as the quatrefoil and fret."

Note 2.p.212. These characteristics of Beotian pottery are indicated according to Böhlau, Böotische Vasen, p. 327-328. (Jahrb. 1888, p. 325-361). Also see Pottier, Catalogue, Part I p. 238-248, and Holleaux, Figurines beotiennes en terre cuite, a decoration geometrique. (Monuments. Piot. Vol.9,p.21-42.pl.3.

Note 3.p.212. Holleoux. Figurines beotiennes. p. 40.

Beotia adjoins Attica. When the potters of Athens had become sufficiently skilful, so that their works had gone beyond the seas, for example to Cyprus, for a stronger reason must they have been carried by commerce among the nearest neighbors of Athens. There have been found in Beotia vases apparently of Attic clay, painting and firing;[4] but beside those imported articles are found in greater number other vases, in which are divined copies of Athenian types executed north of Citheron.

Note 4.p.212. Bohlau. Bottische Vasen. p. 351-353 and Note 17. Holleaux. p. 38. Note 1.

Beotian vases are recognized by their clay, which is less dense than that of the vases of Athens. Small particles of white limestone are mixed with the clay, and show that it was carefully prepared. Its color is pale yellow turning sometimes to red, but which never has the warm tone of the paste of the Dipylon. The turning betrays a certain negligence. The upper edge is not always perfectly horizontal, and the walls are o often needlessly thick. The decoration does not seem laid directly on the clay, as in Attica; it is usually applied on a layer of yellowish white. The color used is a dark brown or a violet red of flat color. Very rare are white touches intended to indicate certain details within the figures. The drawing lacks firmness; lines traced with the brush are heavy; the lines break and start a little farther on; it seems that the painter worked too rapidly.

There is not only something lax in the execution, which denotes the Beotian origin; there is a certain vase that is entirely Attic in form, but whose ornamentation presents peculiarities that change its character. The Beotian decorator has a v very marked preference for the broken line; he uses zigzags to fill compartments in which the Athenian painter preferred to place other designs (Fig. 91). Otherwise most of the motives, the fret, fish, quatrefoils and the band of birds, belong to the repertory of the potters of Athens (Fig. 92); but the broken line ornaments the foot of the vase, and what particularly proves that this was not made at Athens is the white glaze; t there is also a blunder of the copyist, the fish that swims on its back and not on its belly. A little hydria offers motives, all of which we have found on the vases of the Dipylon, the f

fylfot cross, serpent, marsh birds (Fig. 93); but here the swans or cranes are treated in a freer style than at Athens. Likewise on a cup (Fig. 94), beside a great fylfot cross that recalls t the products of Athenian fabrication is found a rosette of two colors, that no longer has the rigidity of the quatrefoils of the Attic painter. The decoration here is everywhere less rich and with an arrangement less wise than at Ceramicos; but there is a more modern appearance on the whole.

Nowhere is more apparent the influence that the Athenian fabrication has exerted on the Beotian than on the amphora, one of whose sides we have reproduced (Fig. 9). On the other is seen the dead reclining (Fig. 95). The theme is that of the great Attic vases placed over the tombs. At the head of the state bed a woman waves a fan over the head of the corpse; it is there like a first sketch of a group that one will later see repeated on the lecythes of Athens. At the foot of the bed a woman takes the dead by the hand and addresses him in a passionate burst of lamentation. At the top are men with swords at th their belts, and at the sides are women in checked clothing; all these persons make the gesture of tearing the hair. Over the couch and between two warriors is perceived a very little figure that seems to run. Is it a child? We have already seen the orphan have his place on two of these vases (Figs. 6 and 60); but the movement of running is poorly explained. Other children appear to have been represented near the bottom of t the picture.

The drawing here presents singular contrasts. Its awkwardness is extreme. However they are clothed, the breasts of the women are indicated, and to show both, the painter has placed them in profile, one above the other. Yet he has a desire to be more accurate than his predecessors. Thus for the men he has not forgotten the baldric, while on the vases that served him as models, the sword hangs at the side without showing how it is attached. Likewise for the human body. In the projection that the brush has given to the hips of the women, there is an effort to come nearer nature. The artist aims at expression. He has desired to make the mouths of the weepers cry aloud; he has emphasized this by separating the lips, between which he e extends the tongue. He does not have the sure hand of the painters of the Dipylon, nor particularly that skill in compositio

that distinguishes them; but in his aspirations, he has advanced beyond them. This painting must have been executed quite late, when in Beotia as well as in Athens art tends to leave the narrow round within which it had been enclosed until then. What further denotes the Beotian origin is this piece, besides the paleness and mediocre quality of the clay, is the incoherent arrangement. The figures are thrown as if by chance on the field. One does not find here that balancing of the groups, which at Athens imparts a certain nobility to the decoration of the vases, even when the execution is most barbaric.

We have been only able to give very brief indications of the local workshops, and on the different species of the geometrical style. Yet this brief survey will have sufficed to illustrate a principal fact, the importance and originality of the role played by the workshops of Athens in the development of this style. Everywhere else that in the provinces, as in Beotia, wh where men are inspired by Attic models, the ceramic painter has only employed the figure as an ornament, that would throw some variety into the monotony of his linear combinations. Doubtless in many vases that came from the excavations of Ceramicos, the figure retains this purely decorative character; but elsewhere it enters into the composition of pictures that have a subject, a subject seized by the spectator at first sight, in spite of the imperfection of the rendering. The Mycenaean painter wi his inventive spirit had indeed attempted something of this kind; but those essays were still timid and were interrupted t to soon to lead to a change in this system. The change was only accomplished in those vases of the Dipylon, where the artist uses the clay as we use canvas, to paint scenes that may be the representation of life. That artist thenceforth entered a natural path; he preludes afar the masterpieces that his heirs will produce from the 6 th to the 4 th centuries.

The Athenian ceramists of the classical age owe much to their obscure predecessors. The potters of the Dipylon received from the Mycenaean potters the secret of this beautiful lustrous black, so resistant, and that their successors continued to employ, at first to fill the outlines of their figures, dark on a light ground, then later to form the glazing of the ground,[1] in the system of vases with red figures. All that chemical analysis has proved, is that this black contains an oxide

of iron; but men have not succeeded in reproducing it, in obtaining a tone that has the same value and the same solidity as the ancient color. By its vigor, by the freedom of the contrast that it produces, this black appears to have so satisfied the potter, who in Athens at least rarely used another tone during a very long time. Where we believe today that we see red, there is most frequently only the effect of badly directed firing. T The red is only burnt black, or black wanting. This is what ca causes thought by more than one vase, where the tint of the d decoration is not everywhere the same. It is black, very frankly black, toward the top of the piece, also black under the ears that form a screen; on the contrary, on the bottom of the vase it changes to red. This is because that lower part of the pot was nearest the souece of heat, the ardent fire. One of the advances made by ceramics will be to learn in time to better regulate the use of the oven, to avoid the flames from the fire. It also seems further, that on many vase in our galleries, this was by the effect of a superoxidation, that the black glaze has changed to black, and to red by prolonged contact with the damp clay; this would be a phenomenon analogous to that which produces rust on iron.

Note 1.p.217. On the black glaze of Greek vases see Durand-Greville. La couleur du decor des vases grecs. (Rev. Arch.1891. p. 99-118); Pottier. catalogue. Part. I. p. 131; Engel. Rev. Arch. 1897. p. 256-257; Lechat. Rev. des etudes grecques. 1898. pa 465. Engel has asked if this glaze is not furnished by a d deep black liquid secreted by the cuttle-fish, and Lechat remarks, that the predilection with which the Mycenaean painters have represented that animal on their vases renders this hypothesis seductive at first view; experiments and analyses are necessary to confirm it.

The Mycenaean painters have frequently employed a slightly bluish white besides red and brown. Later we shall see the Corinthian fabrication add to black, red and violet with touches of white. These examples were not followed at Athens. Why? Were there technical difficulties before which they recoiled? But we have seen what care professional skill is shown by the treatment of enormous vases, that surmounted certain Attic tombs. On the other hand, would this be lack of invention and poverty of mind? But at Athens for the first time the workman imagined the enc-

enclosure in his decoration, of human figures that live and act. If from the beginning the Athenian ceramist abstains from having recourse to those plays of color, this is because he obeys a secret instinct, that manifests itself still more clearly in the work of his successors. His drawing is of the greatest awkwardness, and yet he counts on this to please, on the interest that the spectator will take in the scenes that he has undertaken to represent; he has the ambition to address the intelligence by the intermediary of forms, that he aspires to render expressive, and he labors to obtain this result by the simplest means. In Ionia, at Rhodes, in Beotia, before delivering the vase to the painter, the potter covers it with a white glaze; on that coating the brush will trace the decoration. In Attica that glaze is omitted. What especially occupies the artist is the drawing, whose accuracy and clarity will be better appreciated, as it seems to have been laid directly on the clay.

It is important in this respect to explain once for all, what is meant when one speaks of colors directly laid on the ground. This is a formula that it is proper not to take literally. "All those that have tried to paint, were this a single line on a clay vase, even of polished and burned clay, know how the porosity of the surface makes this simple trace difficult. The clay absorbs like undersized paper. Today to facilitate the work are employed different gummy preparations, that disappear in firing. The Greek ceramists could have used similar processes; yet an attentive examination of their vases causes one to suppose, that frequently before commencing to paint, they covered the entire vase, not only with a transparent varnish, destined to disappear without leaving traces, but also with a solid coating, that retained its own color after firing. Let one examine the personages of vases with red figures and especially the grounds from which are detached the paintings of vases with red figures, and he will prove the presence of a coloring different from that of the clay composing that pottery. This difference will be very easily recognized if one compares the painted surfaces with the bottom or interior of the vase, that generally have not suffered the same preparation. Polishing does not seem sufficient to explain in all cases the variations of tints, which are often very apparent."[1] The difference is still more marked between the tint of the paste in the

fractures and that presented by the paste on the exterior in the panels that have received the decoration. The tint in the thickness of the wall is much more dull and more gray. There is also then the use of a sort of coating, but one of a particular species. The white coating conceals the clay; on the contrary and far from masking it, the Attic glazing accents it; it enhances the tone; it gives to the yellow or red of the clay more accent and warmth; but it renders this service with so m much discretion, that its existence was scarcely suspected until recent times. There is one of those requirements of which we s shall have more than one example to mention in the course of this history of the creations of Greece in relief.

Note 1.p.219. Millet. Un elcythe blanc en forme de gland.p. 3, 4. (Monuments grecs publiees par l'association etc. 1895. This evidence has the greater value since M. Millet is a man of the trade, a ceramic painter. M. Pottier adheres to these conclusions.

With regard to this last development of the geometrical style, which at Athens announced the approaching and raped essay of painting of vases, one asks that the change had been aroused by lessons received from abroad, and the Attic painters must have owed something to oriental models. The decisive response cannot be furnished by history. For the preceding period, Egyptian documents have preserved the trace of the relations then existing between the islands of the Egean sea and the powerful monarchy of th Theban Pharaohs; they have confirmed the inductions suggested to us by certain types found in the excavations of Argolis and of Talysos, which cause one to think of Egypt, and by certain objects, such as scarabeuses with cartouches, w which seem to have been made on the banks of the Nile; we have also proved that the Mycenaean pottery found purchasers in Egypt.[2] For the period opened by the Dorian invasion, one does not have the same resources. After the fall of the Ramessides, Egypt knows little of what passes outside its frontiers. As for Greece, it has no history yet. Then one can only question the epic poems on that subject, in which are collected the most ancient memorials of the Greek race. Now the two poems accord in showing us the Phoenicians frequenting the markets of Greece, and selling them arms, goldsmith's work and jewels. Many episodes even evidence direct relations with Egypt; Menelaus was

driven there by the tempest; Ulysses relates having ravaged the shores of the Delta with a band of pirates and being taken prisoner, and lived for several years in Egypt and Phoenicia. This evidence has its interest; but the difficulty is to know in these tales, what relates to the period when the epic cycle closed, and on the contrary, what is only the echo of the past already distant.

Note 2.p.219. Histoire de l'Art. Vol. VI. p. 1001-1008.

It seems difficult to admit that the events of which Greece was the stage, about a millenium B. C., may have caused the complete suppression of all commerce between Greece on the one hand, and of Syria and Egypt on the other. Rhodes, Cyprus and Crete are too near the coasts of Asia and Africa for men to begin to be ignorant of them after several centuries of contact and of exchanges; but in the new conditions, were not these relations relaxed without abruptly ceasing? What remains of them we know only from the monuments; they alone indicate to us at what time these relations were on the point of interruption, and when they were resumed to become closer and more suggestive, than they had ever been.

There was a time that succeeded nearly all the invasions of the tribes from the North, when the arts of the Orient scarcely exercised any influence on those of Greece. On the vases with purely linear decoration and on those where the figure of an animal only appears as an ornamental motive, nothing betrays the imitation of the exotic repertory. Marsh birds, horses, goats and deer, ibexes, all the animals that are inserted in the panels of the geometrical decoration, live in Greece. Neither lions nor panthers; none of these fabled animals originated in the valleys of the Nile and Euphrates. If the Greeks then continue to demand from foreign merchants some articles of luxury, those reached them in too small number to furnish models for ceramics, the most popular and fertile of all arts.

It is no longer entirely the same for the pottery of the Dipylon. When one makes an inventory of the tombs of the Ceramicos, he finds there ivory and glazed clay with inscriptions in Egyptian characters (Figs. 25, 26); he finds there diadems on which is figured a motive clear to the oriental decorator, the lion leaping on the stag.[1] At this time the ceramic painter also begins to suffer that influence. But he yields it only with regret.

He knows badly the art of beyond the sea; his greatest boldness only goes so far as to take some detail, that when detached from the entirety of which it forms a part, is no in harmony with what surrounds it. We have already had occasion to cite a curious example of this unskilfulness; this is the vase where the artist has introduced between groups of dancers and of musicians the image of two wild beasts facing each other and each at his side, who pull with open mouths at the body of a man, that they have seized in their jaws (Fig. 66). Nothing is more awkward than the execution of this motive. The position that the draftsman has given to the man, suspended in the air between the two beasts is entirely improbable. As for the animals, one does not know at first to what species to assign them. By their long ears, the slender proportions of the muzzle and body, one would say wolves. There is no trace of a mane. Yet one divines from the drawing of the paws the lions that the painter wished to represent; but he never saw a lion. If he had see him leaping among the bushes, he would not have forgotten to mark all the characters with one exception, that form the originality of this type. Such peculiar traits the Mycenaean artist had seized with an intelligent fidelity, that suggests to us that in his time the lion still inhabited the thickets of the mountains of Laconia, Arcady and of central Greece; but four or five centuries had elapsed since then. The population had increased; the thickets had receded before agriculture. The lion must leave the South of the Hellenic peninsula to ascend toward the wilder valleys of Pindus, Olympia and Pangea. He does not appear among the animals of the indigenous fauna on vases where those are represented; then here is the imitation of a foreign model. This group of lions devouring a prey is one of the commonplaces of current ornamentation in all the arts of the Orient. An article decorated by it would fall under the eyes of t the painter. He would be tempted by the exotic color and the novelty of the motive. He would hasten to make use of it, without inquiring whether that scene of a murder would harmonize with the rest of the picture. He has reproduced this theme from memory; if he had the model under his eyes, he would not have changed the form that he pretended to copy.

Note 1.p.220. Athen. Mitt. 1893. p. 108-110.

Elsewhere is no contrast so marked, but the motive borrowed

is not connected with the subject of the picture; it retains the character of a mere filling. Such is the case of a little cup that came from a tomb of the Ceramicos (Fig. 96). Women carrying branches in their hands advance toward a throne, on which is thought to be distinguished a seated personage, a god or goddess.[1] At the other side of the seat are two warriors with their arms and a woman kneeling on a stool, who holds a musical instrument. It is a scene of adoration; but at the end of the actors that play a part in the ceremony appear a sphynx and a winged centaur, that seem to fight each other. Like that of the lions tearing their prey, this group of two monsters facing each other is one of those of which the Asian artist makes most frequent use in the ornamentation of his fabrics and his metal cups.[2]

Note 1.p.222. By the manner in which is presented the figure occupying the throne, this image recalls what we found at Cyprus on a vase, which is an art slightly more advanced. (Histoire de l'Art. Vol. III, Fig. 523).

Note 2.p.222. Histoire de l'Art. Vol. II, Figs. 138, 139, 444, 448; Vol. III, Figs. 552, 565, 625.

Perhaps it is also necessary to recognize the imitation of a motive of the same origin in the group that fills one of the compartments of the decoration of a vase, that although discovered at Cyprus must have been of Athenian manufacture.[3] One sees there two deer that stand against a tree, and between their legs are fawns that seek the udders of their mothers. The same arrangement is painted on the end of an Egyptian box in the form of a house.[4] Finally, a memory of oriental art is the object that occupies a part of the field in the upper band of a cratera of the Dipylon. That image we detach from the entirety.(Fig. 97). One divines there a copy of one of those metal vases in the paintings of Egyptian tombs, that the Syrian tributaries present to the Pharaoh;[1] one finds again here the traits that characterize several of these vases, the slenderness of their feet, their expansion in form of a cratera, the heads of animals that project above the edges, the papyrus stems that rise from the hollow of the wide bowl like a boquet. All is there but curtailed and deformed. The Attic painter had seen one of those pieces of goldsmith's work; but he only knew imperfectly how to render the image of it, that had remained in his memory.[2]

Note 3.p.222. Histoire de l'Art. Vol. III. 514.

Note 4.p.222. Athen. Mitt. 1888. p. 302. B. Graf has just given a new proof of the Attic origin of the vase of Ormido. This group of two deer against a tree, a motive rare in the pottery of the geometrical style, has again been found at Athens on a Pyx, that there is every reason to believe was discovered in t the excavations of the Dipylon. (Athen. Mitt. 1898. p.448-449).

Note 1.p.223. Histoire de l'Art. Vol. III. Fig. 542.

Note 2.p.223. The merit of this comparison belongs to Pottier. (Revue des etudes grecques. 1894. p. 117-132).

These examples will suffice; they show to what was reduced the part made in imitation of the Orient, even in the most advanced period of the life of the geometrical style. The painter of the Dipylon is sometimes inspired by foreign models; but in the use that he makes of them, one divines caprice and accident. These exotic motives are not blended with those that compose the traditional repertory of the artist; they have modified the general appearance of its decoration. In none of the vases that have passed under our eyes have we seen substituted for the fret the garland in which alternate the flowers and buds of the lotus, a garland that a little later will become the n necessary decoration of nearly all painted vases. The borrowings that we have pointed out only possess interest as symptoms of a change of taste that will be prepared and manifest itself at all points of the Greek world; they are too rare for the h historian to prevail on himself for the purpose of separating the fabrication of the Dipylon from the most ancient forms of the geometrical style. All the vases that we have just studied come from that, if not by the choice of themes, at least by t the character of the ornamentation and by the manufacture.

When was accomplished the change that we have just predicted, when the geometrical style gave place to another style, besides the progress of design, the introduction of numerous motives borrowed from oriental models and from themes, that most frequently are taken from epic myths? Only indirectly can one attempt to reply to that question.

As for the initial date, it is given by the Dorian invasion. The geometrical style succeeded the Achaian kingdoms. It would then be toward the end of the 11 th century and in the course of the 10 th that the new system of ornamentation began to be

diffused in Greece. The starting point may be clearly perceived; as for the point attained that marks the end of this development, it is to be sought after the first olympiads, and yet the embarrassment is great when it is necessary to fix on a half century. Not the least vestige of an inscription has been found on any vase or any remains of a vase of the primitive geometrical style, and that which makes no place in the representation of life, so to speak. In even the pottery of the Dipylon, writing appears in even the last years only under the form of scratches;[1] that example was further unique. However interesting was that text in several respects, it did not offer any indication to one that wished to date the pieces; the point of the tool may have incised the clay long after the oenochoe on which it appeared, a vase given as a prize in the games, had left the hands of the workman. In the rubbish of the Acropolis were recently found two fragments of pottery analogous to that of the Dipylon, bits on which are seen some letters traced by the brush on the clay with black glaze before firing;[2] but on the other hand the vases of this sort contained in the museums of Europe by hundreds are all without inscriptions. Thus even during the time when the Attic workshops fabricated pieces, that best represent the advanced geometrical style, if writing was not unknown, it had not yet entered into current use, as it will in the following age, when we shall see it appear on the vases, where is marked the influence of oriental models, the explanatory legends giving the names of the personages.

Note 1.p.224. Athenaion. 1880. Addition to the first Part; Furtwaengler, Zwei Thongefasse aus Athen. (Athen. Mitt. 1881. p. 106-118); Studnicza, Die Attische Inschrift. (Athen. Mitt. p. 225-230). A recent discovery seems to indicate that men then freely made collections of pottery representing the taste of preceding generations. this refers to the great Corinthian amphora, that was found among the remains of vases cast and broken on the funeral pile in the tumulus erected at Marathon to receive the ashes of the Athenians slain in the battle in 490; this amphora cannot be later than the middle of the 6 th century (Deltion. 1890. p. 65-71, 123-32. Pl. IV; 1891, p. 67, 68, 97); Stais (Athen. Mitt. 1893. p. 46-63, pls. 2-5); Houvette. Rapport sur une mission scientifique en Grece. (Nouvelles archives des missions. Vol. II, p. 326-335).

Note 2.p.224. Botho Graf. Ueber die allgemeine Ergebnisse der Vasenfunde von der Akropolis zu Athen. (Arch. Anzeiger. 1893.p17).

Men have sought to date the vases of the Dipylon according to the form of the ships that are represented thereon; they have thought to recognize the pentecontores, that only appeared toward the end of the 8 th century. It is stated that it is not natural, that among a people not then possessing a military marine, one should have the idea of representing combats on t the sea. In the choice of this theme and in the favor that it seems to have enjoyed, men have desired to find the echo and result of the sensation, made throughout all Greece by the great naval battle fought in 664 by the Corinthians and the Corcyrians.[1] The value of these arguments has been contested by very good reasons. The passage of Thucydides to which reference is made does not have the sense attributed to it. The ships copied by the painters of the Dipylon are not pentecontes; they are dieres. We further have so little information on the naval architecture among the Greeks, that it is impossible to know except for the trireme at what time and among what people a certain type made its first appearance. What concerns the moral effect of the shock that occurred between the Corinthians and Corcyreans is still more problematical.[2] Why had not the Athenians thenceforth devoted to maritime affairs, to take pleasure in the image of naval combat?

Note 1.p.225. Kroker. Zeit und Heimat der Dipylonvasen. (Jahr- 1886. p. 106-113).

Note 2.p.225. Pernice. Ueber die Schiffsbilder auf den Dipylonvasen. p. 304-306. (Athen. Mitt. 1892).

If one can hope to leave that uncertainty, it is by pursuing a different path. What is especially important is to know if the art of the Dipylon is contemporaneous with the long elaboration of the Homeric poems, or if it transmitted its evolution only when the Iliad and the Odyssey had already assumed nearly their definite forms, and in that case what interval of time on is right in assuming between the time when the epic poem was composed and that when the potters of the Ceramicos decorated the vases, that ar the masterpieces of the geometrical style.

In the scenes painted on those vases is more than one trait, that corresponds to the descriptions of the epic poems. The ar-

armament of the warriors figured there is the same as that of the heroes of Homer; they have the sword hung to the belt and around the calves are greaves or chemides. Their long hair falls on their shoulders, like that of the Achaians of the poet. The customs seem similar in many respects. A theme frequently t eated in the epics is the tale of expeditions undertaken with a view to pillage, by a band of bold companions.[1] Now several painters of our vases appear to allude to adventures of that kind (Figs. 63, 70). When these paintings were executed, piracy was still the custom. It is the same for the funeral rites. In the paintings that show the pomp of the obsequies, the dead is seen extended on a state bed like Patroclus in the Iliad.[2] At Athens and bęfore Troy, it seems that a chariot race forms a part of the programme; one can interpret as a preparation for the race the series of chariots represented on the vases (Fig. 7), and ask if the tripods seen there are not the prizes intended for the victors (Fig. 8).[3] On more than one piece, the painter has designed a dancing chorus, similar to those that decorate the shield of Achilles (Figs. 59, 96). Only the least details do no show the conformity in customs. In one of those vases in the form of a box, of which several examples have been given (Figs. 46, 63), the coverand the edge of the body are pierced by corresponding holes to receive a cord by which the cover was connected to the box;[4] one remembers that by this procedure Ulysses closed his coffer.

Note 1.p.226. Odyssey. III, 73-105; IX, 38-61, 254; XIV, 85-86, 221-234; XV, 387, 427; XVIII, 423-444, etc.

Note 2.p.226. The same. XVIII. 352.

Note 3.p.226. Iliad. XXII, 164; XXIII, 259, 264, 513.

Note 4.p.226. Monumenti. Vol. IX, pl. 40, 2 and 2 a; Annali. 1872. p. 10.

If certain practices are thus common to the contemporaries of Homer and to the potters of the Dipylon, still more are differences. Certain advances have been made since that time when t the epic cycle was closed. The heros of the epic poem only attached two horses;[1] on the vases are quadrigas (Fig. 93). The Iliad and Odyssey knew the horse only as a draft animal; on several vases of the Dipylon are seen riders (Figs. 99, 100). Finally, the form of ships has changed. According to the epithets that the epic language applies to ships, one has the impressio

that in those the keel described a curve sensibly equal at the bow and the stern. What one divines are the heavy structures with broad sides, built rather to transport merchandize and men than for rapid and aggressive movements, like those that will later be executed by the trireme.[2] On the contrary, those evolutions and murderous shocks appear already possible wit the ships represented on the vases of Ceramicos; their prow extends diminishing beneath the water (Figs. 49, 63). The end of that part becomes a spur to be covered with metal or furnished with a point of iron or bronze.

Note 1.p.227. Teams of four horses are only mentioned in passages, that appear to be interpolations. Helbig. L'epopee, p. 165. Note 2.

Note 2.p.227. Helbig. L'epopee homerique. Chap. 2. At most in one of the more modern parts of the Odyssey is an episode, that without mentioning the spur seems to be explained in a more e satisfactory manner by the hypothesis of a ship equipped with that appendage. This refers to the attack that the suitors meditate against Telemachus. (Odyssey. IV, 669-672; 842-847; XV, 28-30; XVI, 351-357, 364-370). They propose to place themselves in ambush, to attack and sink his ship, when he wished to reenter the port of Ithaca. The attempt seems to have more chance of success, if the vessel making the attack is armed with one of those points.

Finally, on one of the most recent vases of the Dipylon, instead of the great Mycenaean shield with notched sides, one already sees appear the small round shield, that soone will be represented on the vases of the succeeding age (Fig. 58). The potteries of the Dipylon then bear the mark of a civilization more advanced than that whose image is reflected in the epic poems. Now from the entirety of the researches to which the Homeric question has given rise, it appears to result that the date assigned to Homer by Herodotus is still that most probable; this is in the course of the 9 th century that the epic cycle closed. To render a reason for the change introduced in the habits of the Grecian world between that moment and that when the vases of the Dipylon were made, it is necessary to assume that several generations succeeded each other in the interval, and one thus finds placed at about the beginning of the 8 th century the hour at which this art attained its climax. From

the end of that century it must have commenced to go out of f fashion. There are no inscriptions on the vases, while from t the 7 th century were already inscribed on bronze dedications, laws and treaties; now it was easier to trace some letters on clay with the point of the brush, than to engrave them on metal.

We also have another reason for believing that the creative activity of the art of the Dipylon is not prolonged much beyond the first olympiads; this is the character of the themes treated. One does not find these subjects taken from the epic period. This is because that is not yet taken into possession by the Greek mind; it has not yet imposed on that the habit of casting all its ideas in the moulds that it has created. Yet it existed henceforth; but from Ionia where it was born, it had not yet been carried by the voices of the rhapsodists into all Greek cities, from the shores of Scythia and of Thrace to those of Africa, Sicily and Italy. There was necessary a truce of sufficient length for it to extend thus in all directions, to accredit everywhere its language and its fictions, to complete the conquest of all imaginations. The legends added to the figures appeared with the vases on which are recognized the episodes borrowed from either the Iliad and the Odyssey, or from poems lost today, and according to the form of the letters and the orthography, epigraphists do not believe that the most ancient of those inscriptions can be placed much beyond the year 600.

Between the potteries of the Dipylon and the ceramics characterized by the adoption of new themes and the insertion of explanatory legends, it is necessary to find space for another series of vases, for those called proto-Attic. Thus are designated vases that yet present but few inscriptions and scenes of a mythical character, but where is reduced the part given to linear decoration, where the drawing has a freer charm, w where begin to appear motives furnished by oriental models; palm leaves, lions, sphynxes and griffins. Admit that this transitional art with its mixed and undecided style represents the efforts of two or three generations of potters; about the end of the 8 th century the ceramic painter was emboldened to enlarge his repertory and modify his composition. From that moment, progress was continuous and rapid; art was carried into the general flight; it suffered the result of the movement of

expansion, that scattered the Greek colonies over all the shores of the Mediterranean. During the previous period, this advance must have been slower, scarcely sensible from one generation to another.

2. Metal.

From the monuments, and from them alone, have we studied ceramics. Homer knows the potter's wheel; the play of that instrument furnished him with the material for a vivid comparison;[1] but nowhere does he allude to the decoration of vases of clay. The poet has no eyes for products, whose material is without value and that the workshop of the ceramist supplies by hundreds. What arouses his curiosity, what he describes with emphasis to amuse those that hear him, are works of great vaule in which precious metals form varied alloys, where they are juxtaposed to give happy combinations of tones, unexpected and surprising effects. The art of the goldsmith is an aristocratic art, whose masterpieces are transmitted from father to son, or are kept in the treasuries of princes. The beautiful arms, cups of gold or silver, and jewels, thise arouse admiration, and their possession enhances the glory of the hero. The rest, like the clay vase, which forms a part of the furniture of any humble house, has no place assigned in this world of myths and marvels, into which the imagination of the poet transports those of his auditors. The two poems they supply information relating to the history of the arts of the metals, that completes that due to the discoveries made in the tombs.

Note 1.p.229. Iliad. XVIII. 600.

One of the traits most clearly characterizing the Mycenaean age is the introduction of a new metal into use, iron. That h has left only slight traces at Mycenae; it is found there only in tombs belonging to the last time of the primitive period.[1] On the contrary, the Iliad and the Odyssey frequently mention iron; but the heros still have arms only of bronze.

Note 1.p.230. Histoire de l'Art. Vol. VI. 590, 954-955.

At most can one cite the iron club of the Arcadian Arcithoos and the iron spear head of Pandaros.[2] Nowhere is mention of an iron sword; but there is already iron of which are made tools, such as the axe or the skeparnon, which served for working wood.[3] There are also iron axes, that Achilles gives as prizes in the games, and Telemachus places in the great hall of the palace

for the archery.[4]

Note 2.p.230. Iliad. VII. 123, 141, 144.

Note 3.p.230. Iliad. IV. 485; Odyssey. IX. 391-393.

Note 4.p.230. Iliad. XXIII. 850; Odyssey. XIX, 578, 587; XXI.3.

The tombs of th Dipylon are evidence of other customs. The sword is there always of iron; it is the same with knives and arrow heads;[5] bu one would err in concluding it necessary to necessary to assume a very long interval of time between the hour when the epic cycle closed and that when the cemetery began. The ceramic painter reproduced the scenes under his eyes, while the epic singers adhered to representing a past long since. If Homer gives his heros bronze swords, this is because he knows that these were the arms of heros of former times, of those whose prowess he relates; in attributing these to them, he gives in his way what we term local color; when epic poetry flourished, the iron sword had perhaps already come into use. That would be suggested by a trait that does not seem to accord with the general themes of his poems. We mean a verse that occurs twice in the Odyssey. (Greek).[6]

"O itself the iron carries away the man," i.e.,"when man has the iron in his hand, he finds himself, even without willing it, led to commit acts of violence." That formula could only originate and form a proverb in a century, when oron especially served for fighting; the iron is mere particularly the arm that slays. There is only the appearance of a contradiction. By its origin, the epic period goes back to the extensive reign of bronze; but when it ended, already from iron were required almost all the services formerly expected from bronze. This iron was wrought by the Greeks themselves. This suffices to demonstrate this by a comparison borrowed from the process of tempering in cold water; the poet says,"that gives to iron all its strength."[1]

Also hear Achilles, when he presents the iron disk that the competitors must roll on the sand of the shore. "This disk will be the prize of the victor, and whatever the extent of his domain, he will find in this mass of metal sufficient for at least five years, to fabricate all the tools needed by his shepherds and laborers."[2]

Note 5.p.230. Athen. Mitt. 1892, p. 297; 1893, p. 100, 139.

Note 6.p.230. O yssey. XVI, 294 XIX, 13.

Note 1.p.231. Odyssey. IX, 391-393.

Note 2.p.231. Iliad. XXIII. 831-835.

If from the 9 th century iron were used for making all the tools intended to split or cut clay and stone, wood and living flesh, men even then continued to make very varied uses of bronze. Melted and cast in a mould, it furnished to the sculptor a material less exposed to the chance of destruction than clay, and more easily wrought than limestone tufa or marble. Beaten with the hammer, it takes all the forms that the workman desires to give it; he extends and draws it into rings, round or square rods, suited to compose all kinds of objects for the toilet or utensils of the house. It is no less easily reduced to flat bands or sheets more or less thin, that are covered by designs engraved with the point or raised with the chisel, applied with the aid of nails on wood, and serving to face shields, chariots, coffers and furniture of all sorts. Treated by the procedure of drawing out, the same metal gave great caldrons, that formed the upper part of tripods. For vessels of the same kind that served for domestic uses and kitchen utensils, men were contented with copper; that cost less and was more malleable.

Silver and gold found their uses in objects of luxury. It does not appear from the time of Homer, that there were anywhere in the Grecian world accumulations of the precious metals comparable to those produced in the castles of Achaian princes in the course of the preceding age. That is evidenced by the memory left in tradition by the extraordinary wealth of Mycenae; it is also divined from the language of the poet, when he has occasion to mention arms of price or pieces of goldsmith's work. He does not fail to attribute their execution to Hephaestos, the divine artist, or to the Phoenicians, he speaks of it with an admiration, which suggests that he did not have many works of that kind under his eyes. On the contrary, these exist in great number in the treasuries of the Perseides and Pelopides, so that in that respect a contemporary of those princes was not affected by the surprise, that we believe a trace is felt in the descriptions of epic poets.

In the course of the troubles, struggles and displacements of the tribes, that was the result of the invasion of the men from the North, the reserves of the precious metals formed in their treasuries by the chiefs of the old dynasties must have disapp-

disappeared very quickly. The tombs retained their deposits; but of objects of goldsmith's work not entrusted to that safe shelter, more were pillaged, broken up or melted; very few of them could pass intact into the hands of the conquerors, or be preserved by the heirs of their ancient possessors. Yet there must have been waifs from that shipwreck, in several works of metal described in the epic poems one is inclined to recognize the themes and motives of the Mycenaean industry. Here for example is the stephanos, the diadem of gold, that to please Zeus, Hephaestos has made to ornament the head of Pandora.

"In the metal he chiseled many varied ornaments, admirable to see
Animals, all those nourished by the land or the sea.
He places many of them; the work was most elegant;
It was a marvel; one would call them beings endowed with life and voices."[1]

Note 1.p.232. Hesiod. Theogony. 578-584. The word "pollon" is repeated twice.

One is here very far from the dryness of the geometrical style; a different spirit inspires that effort to reproduce in their diversity the forms of the organic world. In the ornamentation of the diadem of Pandora, the fishes alone cannot represent the maritime fauna; beside them must figure the cuttle-fishes, the nautiluses, all those strange types, which at Mycenae filled the fields of the jewels and those of vases of clay.

In regard to sculpture, we have mentioned the group that decorated the outer face of the brooch of Ulysses, a dog holding between his paws a fawn that argues.[2] This theme has been found more than once in the Mycenaean monuments; we have seen there a lion, a sphynx or a griffin, who strangles a stag.[1]

Note 2.p.232. Odyssey. XIX. 228-231. See p. 119 above.

Note 1.p.233. Histoire de l'Art. Vol. VI. Figs. 405, 403, 409, 414, 428 9; Pls. XVI, 8-21.

One of the works that the poet describes with more complacency is the cuirass of Agamemnon.[2] It was given by Kinyras, king of Cyprus; one is then tempted to see in it a product of Phoenician industry. We have further not found at Mycenae the serpents that are erect on each of the two plates, whose junction by thongs protected the bust of the warrior; it is on the ceramics of the Dipylon, that we have found on several vases a motive of that kind (Figs. 69, 89). On the other hand, the mode

of execution of the decoration on the cuirass recalls the procedures of the Mycenaean workman. The technics are just those studied in the celebrated daggers taken from the tombs of the acropolis at Mycenae.[3] Here the theme is of a white metal, cassiteros, gold and the kyenos or copper blue, are inlaid in a bronze plate, forming a sort of mosaic. The serpents were in kyanos; now we know by the frieze of the palace of Tiryns, what an important part in ornamentation that material played, which commerce brought from Egypt and especially from Cyprus.[4] It a appears that with this blue enamel was also employed a white enamel, that is called titanos; in his description of the shield of Hercules, Hesiod mentions titanos beside ivory and electrum, whose whiteness he seems to contrast with the gleam of gold.[5]

Note 2.p.233. Iliad. XI. 19-28. On the decoration of the cuirass, see Helbig, L'epopee. p. 491-498.

Note 3.p.233. Histoire de l'Art. Vol. VI. p. 779-784; pls. 17, 18, 19.

Note 4.p.233. The same. Vol. VI. p. 545-546, 559-560.

Note 5.p.233. Hesiod. Shield. Verse 141-143; Studnicsa. Ueber den Schild des Herokles. p. 52. No. 5.

The epic language frequently employs in relation to goldsmith's works certain expressions, that should not be taken literally. It mentions staves and sceptres, shuttles and spindles, baskets and golden seats.[6] The basket for tapestry of Helen, the tables of Circe, the coffer in which Hephaestos keeps his tools, were of silver.[7] This is only a mode of speech. Of little importance to the poet is the nature or the internal composition of the objects that he presents to the eyes. Whenever he has seen the yellow of the gold gleam or the mild whiteness of silver, he mentions those metals without asking what is behind those surfaces, whose splendor caresses and charms his eyes. What touches him, what he expresses is his visual sensation, the impression that he has received. Most of the furniture enumerated above is what in real life, even when the taste for luxury was most extended, was never made of gold or of solid silver, but was freely gilded or silvered; such as the sceptres and seats, tables and coffers. What would farther suffice to remove all doubts, is, that the poet employs the same expressions, "chryseos, argyreos," in regard to other objects, where

metal could only play the part of a covering. He speaks of golden reins;[1] but those reins could have been made only of an el elastic and supple material, such as leather. The same observation for sandals, sword pendants, baldrics, to which are attached the same epithets. What is understood is, that in certain cases by means of glue or by a proce s analogous to damascening, on those straps were applied thin leaves of gold or silver. As for coffers, tables, the carts of chariots, on them were fixed by little nails, bands of metal by which the wood was loncealed. Very numerous fragments of those coverings have been found in the excavations of the Dipylon, and especially in those of Dodona and of Olympia. (Figs. 34, 35).

Note 6.p.233. Odyssey. XVI, 172; XXIV, 2; V, 87; X, 277, 384; Iliad. I, 14; II, 268; Odyssey, XIX, 91, 569; IV, 131; V, 62, 355; Iliad, VIII, 436, 442; XIV, 238.

Note 7.p.233. Odyssey, IV, 125, 131; X, 354; Iliad, XXIII, 419.

Note 1.p.234. "Chryseenlos," epithet of Artemis and Ares, Iliad VI, 205; Odyssey, VIII, 285.

A material that the goldsmiths and the jeweller caused to enter into the composition of their works is what Homer calls c cassiteros. This word is ordinarily translated by tin; but one has never found in Greece any object dating from either the p primitive or the classical ages, in which pure tin is employed.[2] Wherever Greece obtained it, tin came too far and in too small quantities for one to think of using it like the other metals, whose ores were within reach; it seems to have been used only to mix with copper, so as to obtain thus an alloy, bronze, precious among all others.

Note 2.p.234. All that Helbig found to cite is a bronze belt discovered in the cemetery of Alifae (Samnium), on which is thought to be perceived traces of tinning. (L'epopee, p. 263. 1.

It has further been demonstrated by the most authoritative of the historians of metallurgy, that the Greek word cassiteros a and the Latin stamnum are only late, the first under the Ptolemies and the second in the last times of the Roman empire, re received the special and clearly definite sense, that we today attribute to the word tin, derived from stamnum.[3] The practice of the workshops must know how to distinguish tin from other metals; but in the current use of the language it was treated as a simple variety of lead; it was the white lead in contrast

to the black lead, the lead properly so called. As for the term stamnum, Pliny sometimes applies it to real tin, sometimes to a mineral of argentiferous lead, that does not contain a particle of tin.[1]

Note 3.p.234. Introduction a l'etude de la Chimie des anciens et du moyen age. p. 250-251. La Chimie au moyen age. Vol. I. p. 367-368.

Note 1.p.235. Pliny. H. N. XXIV. 47.

What is then probable is, that for the contempories of Homer, this word cassiteros designates an alloy of silver and lead, which perhaps also contained some parts of tin. The color given by that alloy was different from that of silver; the artist thus varied the tones.

If it results from these descriptions, that the workers in metal were simply the continuators of their Mycenaean predecessors, it no less results that like them, these workmen were in relations with the Phoenician workshops, from which they derived the works that served them as models. Thoas, king of the Thracians and Lemnos received a cratera of silver as a present from the mariners of Sidon, "the most beautiful that there i on earth."[2] To Menelaus , Phaedimos, king of the Sidonians, gave another vase of the same material and same form, whose edges were bordered by a circle of gold.[3] The cuirass of Agamemnon came from Cyprus, a country half Phoenician. There is also a necklace of gold and amber, that is shown to the women, in order to introduce themselves into the house of the king, by the Phoenician merchants, who carry off Eumea while yet a child.[4] It is one of those ample necklaces in several rows ornamented by beads, that falls on the chest between the breasts, and was called "hormoi;" we have found more than one example at Cyprus.[5] In the epic period, one sees the Phoenicians visit Egypt,[6] and at the same time Crete,[7] Lemnos,[8] Ithaca [9] and the Cyclades.[10] Their ships are everywhere in the eastern basin of the Medittерranean. These statements accord with the traditions, that a among the Greeks are connected with the birth and progress of metallurgy, with the intervention of superhuman workmen, the Cabires and the Telchines, to whom the myth assigns as domiciles those of the Grecian lands, that had been most frequented by the Phoenicians. It takes the telchines from the island of Crete to those of Rhodes and of Cyprus. As for the Cabires, it

places them in Beotia, at Thasos, Lemnos, Imbros and especially at Samothrace, where up to the last days of antiquity, their sanctuary and the mysteries celebrated there were in great honor.

Note 2.p.235. Iliad. XXIII. 741-745.

Note 3.p.235. Odyssey. IV. 615-619.

Note 4.p.235. Odyssey. XV. 460.

Note 5.p.235. Histoire de l'Art. Vol. III. Fig. 196.

Note 6.p.235. Odyssey. XIV. 288.

Note 7.p.235. Odyssey. XIII. 273.

Note 8.p.235. Iliad. XII. 745.

Note 9.p.235. Odyssey. XV. 482.

Note10.p.235. Odyssey. XV. 415.

The monuments confirm the deductions that we have made from a study of the poems. They are in small number, but they present the double character that we believed could be seen in the works described by the poet. One there feels both the persistent influence of Mycenaean industry and that of the arts of the Orient. As for the geometrical style, the only one then practised by t the ceramic painter, it had but slight effect on the habits and taste of the goldsmith. All that it recalls at great intervals are some details of secondary importance, such as that of the enclosures into the composition of which enters the fret, and also the figures in which one finds the systematic alterations of the form, that are suited to the design of the decorators of the Dipylon.

To justify these assertions it suffices to examine the objects composing a treasure acquired in 1882 by the British Museum.[1] All that one knows of these objects is, that they were found together at Egina. According to all appearance, they formed the equipment of a tomb; but at what point of the island was that sepulchre, and what was its arrangement? That is what we are always ignorant of. By causing clandestine excavations, the unintelligent rigor of the Grecian law opposes its purpose; it does not succeed in preventing antiquities from passing the frontier; but deprives archaeologists of precious information, that without those vain menaces, one would have no reason to r refuse them.

Note 1.p.236. A very complete and exact description of all the pieces composing this treasure has been given by M. Arthur J. Evans under the title:- A Mykenaean treasure from Egina.

(Jour. Hell. Stud. Vol. XIII. 1891-1893. p. 195-226). S. Reinach. La Sculpture in Europe etc. p. 95-98. 1896.

Gold is the only metal that enters into the composition of these jewels; it is combined with cornelians, amethysts and glass pastes. What is first striking are the traits that recall the motives and procedures of Mycenaean art. Here is a cup of very pure gold that weighs 1290 grains (Figs. 101, 102). It had only one ear; the three holes are visible that served for attaching that handle. The form of the cup is not that affected by the goblets found in the tombs of Mycenae; it is more flattened; but what forms the resemblance is the decoration. It consists of a star rosette, that occupies the bottom of the vase, and of four connected spirals symmetrically arranged outside it on t the wall. At Mycenae a pitcher exhibits the same sort of ornament.[1]

Note 1.p.237. Histoire de l'Art. Vol. V. Fig. 24.

This same motive, in which one recognizes as reduced to less width, decorates one of those diadems that encircled to brows of the dead at Mycenae (Fig. 103).[2] The form and mode of attachment are similar. There are also at Mycenae examples of designs traced in dotted lines.[3]

Note 2.p.237. Histoire de l'Art. Vol. VI. Figs. 538, 539.

Note 3.p.237. Schliemann. Mycenes. Fig. 370.

What more than all else arouses here the memory of Mycenae are plates of gold, of the kind of those taken by hundreds from the pits of the funerary enclosure.[4] At Egina have been found 54 examples of the same pattern (Fig. 104). At the middle is a rosette with eight leaves, enclosed in a border in which we find again the spiral. As in the round pieces collected by Schliemann are perceived very small holes pierced near the circumference. These plates from Egina likewise must have been sewn on a vestment for a glittering covering of some royal corpse. Finally, one notes rings of solid gold, whose surfaces are the same as those of the rings of Mycenae (Fig. 105);[1] but here is no bezel with an image. The rings are simpler, as the plates and diadems are of smaller dimensions, and the designs have less relief and freedom.

Note 4.p.237. Histoire de l'Art. Vol. VI. Figs. 540-543.

Note 1.p.238. The same. Vol. VI. Figs. 520, 421, 549.

Not alone by the choice of types is the goldsmith of Egina

connected with that of Mycenae; he has inherited certain procedures from him. One finds here the blue glass of Tiryns, the kyanos of Homer. On the exteriors of several rings the design is engraved in intaglio in the thickness of the metal. Very small bits of that paste have been inserted in cavities; some bits remain. Thus has been obtained nearly the effect of our champleve enamels. Another borrowing from earlier technics is the precaution taken to double the plates wrought or raised. Thus more solidity is given; thus were made the cups of Vaphio.[2] The same procedure was applied to several pieces of the treasure. The sheet that forms the double is a little larger than the other; its border is folded like a hem, on which the contour received the ornamentation.

Note 2.p.238. Histoire de l'Art. Vol. VI. p. 785.

Beside objects that one could almost believe taken from a Mycenaean workshop, there are others on which the imitation of oriental types is very sensible, more so than usual at Mycenae. Such is the case for a jewel, doubtless for a pendant of a necklace. The motive is a person standing in a sort of a boat between four branches curved around him and terminated by a button; each of his extended arms grasp the neck of a duck (Fig. 106). One will note the plumes surrounding the head; without reproducing an arrangement that might be peculiar to a certain god, they make one think of several Egyptian divinities. In the two rings projecting right and left of the neck, it is believed that one sees a memorial of the great loops formed by the hair of Hathor. Nothing conforms more to the Egyptian fashion than the arrangement of the bracelets, placed near the shoulder and on the wrist. The legs and bust are nude. For all clothing, a drawers enclose the hips; this is the shenti with the wide band of striped fabric that falls in front to the height of the knee. In Egypt that terminates in the costumes of gods and kings by a series of uraeuses; here that ornament is wanting. According to the rule constantly followed by Egyptian art, the figure has the left leg in front. Finally, at the centre and the two ends the boat is decorated by lotus flowers. A boat whose bow and stern present the same design is frequently found serving as a support, either in Egyptian works or in the works of Egyptian style, that the Phoenicians scattered along the Mediterranean.[?]

Note 1.p.239. Histoire de l'Art. Vol. I. Fig. 586.

Note 2.p.239. Histoire de l'Art. Vol. III. Figs. 38, 623.

There is in this figure something of Osiris, whose hair and clothing are very much simplified; but there being given the ducks seized by the personage, one is rather tempted to seek a the first idea of the motive in a theme, of which the decorators of the Egyptian tomb made frequent use, in that of a hunter mounted on a light boat, who pursues the marsh birds among the tangled stems of the papyrus an reeds.[3]

Note 3.p.239. Histoire de l'Art. Vol. I. Fig. 8.

The memory of Egypt evokes all these traits; yet one will not find in the paintings of the hypogeums a hunting scene, where the captured birds present the rigorous symmetry that is striking here. This arrangement is rather found in Assyria,[1] as well as on the Mycenaean intaglios; in those one finds the type that archaeologists designate by the term of Persian Artemis, a type that by the movement of the figure, holding with each arm a b bird or a hare, also recalls the personage of the jewel of Egina.[2] This heraldic style, as it has been called, is of Asian origin. Otherwise the figure, all Egyptian as it may be by certain traits, is not the literal copy of any type created by t the art of Egypt. Then the jeuel was not fabricated in the Delta, and it also has not the appearance of having left the workshops of Sidon; the Phoenician adheres more closely to his model. What one feels here is that it is the result of vague and multiple reminiscences, that at the risk of opposing each other, are added and mixed together. The artisan had under his e eyes objects of foreign origin; he profits by two memories to avoid a literal copy.

Note 1.p.240. Histoire de l'Art. Vol. II. Figs. 331, 388, 408, 443, 444, 448.

Note 2.p.240. The same. Vol. VI. Figs. 426,[21] 428,[32] 431,[10] 432[2,7].

The influence of oriental art again makes itself felt, but this time by a unique detail in another object, that must also be the central part of a necklace (Fig. 107). In the frame forming a circle terminated by two serpent's heads, there are four figures of animals grouped in pairs, two dogs facing each other, with one paw raised and holding a cornelian bead, and two apes back to back and holding one hand to the nose. These figures are very slender in proportions and are made of this sheets of gold; little chains and rings if ingenious arrangement connect

them to the frame.

Attached to the fate of man much before the beginning of the historic age and in the entire extent of the ancient world, t the dog as an art type has no country. As for the ape, Greece knew him only by hearsay, or rather by his image that it found on the monuments of Egypto-Phoenician industry. The Egyptians derived the ape from Ethiopia; they had consecrated it to Thoth, and thus had made a place for it in the paintings in which were represented the scenes of their worship. On the other hand, one does not know where to seek the origin of another motive, the screech owls that alternate with disks as pendants. That bird is not one of those utilized by the oriental ornamentist as m motives of decoration; nor does it from a part of the repertory of the ceramic painters of the Dipylon; on the contrary, Grecian art of the classical age had a certain predilection for it.

Ducks with expanded wings take the place of the screech owls in another jewel, which has for principal ornament a lion's head seen in front, which a stiff stem connects with another piece in the form of a boat (Fig. 108). Between the two is a space; the intermediate part has disappeared; it was made of a less resistant material, amber or ivory. Assuming it restored, one obtains an entirety that must recall the jewel that Egyptologists designate by the name of ægis (breastplate), a richly decorated plate at the top of which is shown the face of Sekket, the goddess with a lion's head.[1]

Note 1.p.241. Vol. I. Fig. 369.

One feels himself also no nearer Egypt, with two heads executed in relief, that form the ends of a metal band curved in half moon shape, from which are suspended light disks (Fig. 109). By the character of the lines and the arrangement of the hair, those heads resemble those of the ivory sphynx, that came from the northwest palace at Nimroud, and which are perhaps Phoenician. Inserted in the hollows of the metal, scales of blue g glass represent the arch of the eyebrows and the globe of the eye.

Several necklaces are made of gold beads, that alternate with beads of cornelian. Among the pieces that entered into the composition of one of these decorations is one curious ornament; it is a golden pear enclosed in an open hand (Fig. 110). In that pear is thought to be recognized a woman's breast, and one re-

recalls the gesture of Isis, who placed her hands on her chest, when she suckled Horus.[1] To that gesture, a symbol of fertility, the goldsmith is said to have alluded in creating this motive. We have difficulty in believing it. With the arrangement adopted here the gesture would no longer have any sense. The fingers would vainly press the breast, as the palm of the hand applied on the nipple would close the passage of the milk. There is a much simpler explanation. What the workman desired to represent is a fruit seized by its base by the hand that picks it, a fruit that would be a pear or pomegranate. Here is what confirms this conjecture; beneath each of these large pieces is another fruit, easily recognized. Nothing is more natural than to connect thus two objects of the same species to compose a unique ornament.

Note 1.p.242. A Mykenean treasure. p. 208.

Other necklaces have nothing to say, unless their gold beads placed side by side recall the beads of glazed faience, that abound in Egyptian tombs of the 10 th and 9 th centuries (Fig. 111). Note also that the bezel of one ring has the form of a notched shield, whose contour is the same as that of the shield that decorates the coins of Salamis and Beotian coins (Figs. 112) The shield with double notches appears to have been in use in ancient times among very different peoples. One meets with it both among the Heteans, the Mycenaeans and on the vases of the Dipylon. We do not know if the contemporaries of Herodotus and of Thucydider stell protected their arms with it; but the place that it occupies on the coins in questing suffices to prove t that there had not been lost the memory of the services formerly rendered by it. It does not seem that one could derive from the use made here of this type any indication, either of the p place of fabrication of these jewels, or of the date to be assigned to them. If one chanced to solve this double problem, it is not by depending on a certain isolated peculiarity, but by considering the entirety of the observations given by those finds, that have seemed most worthy of attention.

The first question proposed is that of knowing if these jewels all have the same origin, and in case of an affirmative reply, what is the workshop that produced them. On the first point, we believe that one cannot hesitate. Doubtless no two jewels are alike. The motives vary in all; but they no less have a common

character; where they are not in the pure Mycenaean tradition, there the art is inpsired by themes familiar to Egypt, Phoenicia and Assyria, the imitation is always at some distance from the model. Finally, the same materials are everywhere employed, with the same procedures of execution. These ornaments are from a single source; they come from the same workshop. Shall we s seek that workshop outside of Greece? But in that case, what we must find in the decoration of these jewels would not be a vague reflection of the style and taste of the arts of the Orient; we should recognize, as if by its mark of the workshop, certain of the exotic industries whose products were carried by Syrian merchants to the shores of the Peloponessus; finally, we do not find these Mycenaean elements that we have mentioned. All these jewels are indeed the work of Grecian goldsmiths, and probably of one establishment at Egina. One knows what was the naval power and the commerce of Egina in the 7 th and 6 th centuries, what position its merchants held at Naucratis and the Delta, and with what beautiful monuments they ornamented their island on the eve of the Median wars; but this prosperity appears to date back in the past beyond the time when history commences. Egina was marvellously situated in the middle of the Saronic gulf, between the coasts of Argolis and those of Attica on the route to Corinth. In verses not to be taken literally, but which no less evidence the reputation enjoyed by the mariners of Egina, one of the poets whose works collected under the name of Hesiod, attributed to the Eginetans the honor of having been the first to "provide the ship with sails, the wings that make it slide over the waves."[1] Excavations have brought to light at various points of the island fragments of vases, some of which belong to Mycenaean pottery, while others appear contemporaries of the pottery of the Dipylon.[2] In those with very unusual forms is believed to be recognized the products of local workshops.

Note 1.p.244. Hesiod. Catal. fragm. 98. Edit. Kinkel.

Note 2.p.244. Stais. Ephemeris. 1895. p. 241,262,263,Pl.12.

It is more difficult but perhaps not impossible to arrive at a probable conjecture concerning the age of these jewels. To a about the 9 th century we refer some relations that can be established between certain details of the work on these jewels a and the oriental models that passed under the eyes of the Greek

artist; but what is more significant is the fact itself of these borrowings. They are numerous and their sources are different. One divines that from the appearance of the Achaian states of Crete, of the Peloponnessus, of Attica and of Beotia, the Syrian ships more freely frequented the seas of Greece, and that the decadence of Grecian industry gave more vogue to the types of which they are the propagators. One sees the moment approach, when after the disappearance of the Mycenaean style and the rectilinear geometrical style that succeeded it, before developing its full originality, the Greek ornamentist placed himself at the school of the arts of the Orient as a docile and curious pupil. But on the other hand the workman has not yet forgotten the forms and motives of Mycenaean art; but he reduces those f forms and simplifies those motives. Then otherwise an entire portion of the repertory of his predecessors, the most singular, that he seems to have repudiated. If he still amuses himself with the play of spirals, he no longer demands anything from the fauna and flora of Grecian seas; here are neither scrolls of algae, nautilus, nor cuttle-fishes with long wavy arms. One feels himself in presence of an art that survives in itself, that is not dead, but whose days are counted; this is the end, and one can almost say, that this is the tail of a style and of a tradition. However, all enfeebled as may be this tradition, it still persists, and that persistence suffices to warn us that with these jewels we cannot be very far from the time, when the Dorian invasion commenced to trouble the Achaian world. To fix approximately the date of fabrication of the objects composing the treasure of Egina, we should incline to go back to the 10 th century, or in any case to not pass the first half of the 9 th.[1]

Note 1.p.243. Evans comes down a little later; he places the fabrication of those jewels at about the year 800.

By this find we shall then have an idea of the style and the taste that must have reigned in Greece during the first half of the period in which our researches extend in the districts that the war had spared most. On the contrary, the art of the closing 9 th century and that of the 8 th century, the art contemporaneous with the most advanced potteries of the Dipylon, that we recognize in the plates of gold ornamented by stamped designs, which have been found in many necropolises of Greece and

particularly in the tombs of Ceramicos at Athens. These were diadems that enclosed the heads of the dead, or bands that on the funerary bed served to support the chin.[2] The ornament with the space occupied by chevrons, frets and the flyfot cross, is there conceived in the spirit of the rectilinear geometrical style. As on the vases, the fret encloses the figure, that of a man and an animal. There are subjects of pure fancy, whose theme is borrowed either from Mycenaean intaglios, where they are already found, or from oriental art, that also furnishes the model; this is a man overthrown between two lions (Fig. 113); there are also stags pursued and attacked by lions (Fig. 114).[3]

Note 2.p.245. On this use of bands of gold, see Wolters. Ein griechischer Bestattungsgebrauch. (Athen. Mitt. 1898. p.267-371).

Note 3.p.245. This diadem was acquired at Athens by Piot. It had just been found in a tomb of Ceramicos.

The theme is everywhere very simple and purely decorative; but on others of these bands the goldsmith, like the ceramic painter, attempted to reproduce scenes more or less directly taken from real life; Here is a band that came from Athens, and that seems to represent a festal procession, the bringing of a sacrifice; one sees represented there the horsemen, armed men that march in line with cadenced steps, women, men that carry a victim and the knife with which he will slay it. A curious detail is the presence of centaurs in this procession; of these monsters, some have the front legs like those of horses, the others like those of men (Fig. 115).[1] Elsewhere on the bands discovered at Athens, one is present at battles' among the combatant are centaurs, who either contend with each other or against men.[2] On another diadem figure the sphynx and the griffin; they have on their heads that sort of plume falling from behind, that Mycenaean art already gives to those monsters.[2] A sign of the times is the part here given to these artificial types. The mind of the artist begins to be nourished by myths developed by poetry, myths in which is played a great part by all those composite beings, some of which have been borrowed from the Orient by Greece, while others appear to be the real children of the Grecian imagination.

Note 1.p.246. Furtwängler. Archaischer Goldschmuck.(Arch. Zeit. 1884. §. 99-114. pls. 8 and 9.

Note 2.p.246. The same. Pl IX, 1.

Note 3.p.246. The same. Pl. X, 1.

As for the style of these jewels, it remains very inferior to that of the masterpieces of Mycenaean goldsmith's work. There is nothing, that for the art of composition and especially for the bold freedom of the touch, is even afar comparable to the cups of Vaphio. Here the image is obtained by the pressure exerted by the hammer on the sheet of metal, that it forces to enter the hollows of the mould. With whatever care this operation was performed, one could thus obtain only outlines without firmness, and were again softened later; the sheet of gold is too thin to resist the least shock. To ornament the entire band, it is further necessary to apply it several times to the mould, in which was cut a motive, that was repeated as many times as the piece to be decorated required by the length of the plate; now the connections were generally executed with a certain negligence; here the figures overlay each other; there is too great an interval between them. Finally, the mechanical character of the procedure suffices of itself to explain the mediocrity of the work. The fabrication of the stamped bands was an industry rather than an art. Bands stamped by means of the same matrix are found in different tombs at Ceramicos.[1]

Note 1.p.247. Athen. Mitt. 1893. p. 127.

There is then here a difference between the work of the ceramic painter and that of the goldsmith, that may be as marked as that which struck us, when we were writing the history of Mycenaean art. The goldsmith has not advanced much; this is perhaps because he is no longer the servant of the king and the purveyor of his luxury; if he does not labor for the multitude, but at least for all the wealthy. What these require from him are jewels containing little material, that serve t the purpose without costing dear. There is then a very sensible analogy between the figures of these gold plates and those of the vases of the Dipylon. The same alteration and reduction of the living form; the same angular drawing that comes from habits contracted in the school of geometrical decoration. Yet it seems that the fabrication of the goldsmith may be a little less dry and hard than that of the painter. With him the poses have more variety; the general proportions of the body of the man are better observed. The drawing of the trunk and the members, although still very summary, yet is more round. One cannot

find on any vase of this period animals that equal those of one of the diadems (Fig. 115). If the lions remain with an entirely conventional rendering, the stags are supple and have a very correct movement.

From the point of view of taste and decoration, what establishes a closer connection between the arts of metal and those of clay is the brooch, i.e., the safety pin or clasp that serves to drape the fabric, to fix its folds, and to connect its edges. Under the simplest form, the brooch is composed of a pin or tongue, of a body more or less round, to which the tongue is fastened at top, and a notch, ring or hook, in which that body ends at its lower end. If the tongue be engaged in the hook, the desired connection was made' the piece could no longer move.

Men have occupied themselves much with the brooch in the last years. A list has been made of all layers in which it is found; there have been described all forms taken by it in the course of the ages in different countries.[1] What results from these researches is, that neither Chaldea, Assyria, Egypt nor Phoenicia knew the brooch, and tha it made its appearance in Italy among the peoples of the seacoast of Italy, as well as in the valley of the Po, and in Greece about the end of the Mycenaean period. Several examples have been found at Mycenae, but in very small number, and only in the more recent deposits.[1] On the contrary, one certainly meets with it in the tombs of the period that opens by that invasion, and thenceforth we find it everywhere, as well in central Europe as among the coastal inhabitants of the Mediterranean.

Note 1.p.248. As a substantial summary of all these researches, see the article Fibula by Solomon Reinach in the Dictionary of Daremberg and Saglio. One will find there a very rich bibliography. We shall limit ourselves to citing the works of a nature to interest us most, in the sense that they relate more particularly to the history of the brooch among the Greeks and among the peoples from which they could have borrowed it.

Undset. Sur les plus anciens types de fibules et les fibules de provenance grecque. Zeit. fur Ethn. 1889. p. 205-234).

Studniczo. Zur Herkunft der mykenischen Cultur. (Athen. Mitt. XII. p.8-24).

Bohlau. Beschreibung der Bronzen aus den Beotischen Graben. (Jahrb. der arch. Inst. 1888. p. 381-384).

De Ridder. Catalogue des bronzes de la Societe archaeologique d'Athen. p. 55-61.

P. Wolters. (Ephemeris. 1829. p. 232 and pl. 11).

Helbig. L'epopee homerique. Chap. VI. p. 105.

Collignon. Note sur des febules beotiennes a decor grave. (Memoires de la Societe nationales des Antiquaries. Vol. LV. 1896).

Note 1.p.249. This rule seems to admit of some exceptions, but which if more closely observed do not appear to weaken the principle stated here. M. de Luschan has discovered in the British Museum several brooches of a very peculiar type, that come from Nimroud; but those objects are not earlier than the year 800, and it remains very probable that their model was brought from the West. (Verh. der Berl. Anthr. Ges. 1892. p. 287).One can say as much of the brooch that the chisel of the sculptor has represented on the breast of a god at Ibriz in Cappadocia. (Histoire de l'Art. Vol. IV. p. 724, Fig. 354). This rock-cut relief is also probably later than the time when the brooch b become in general use in the West.

It is then very probable that the use of it was introduced into Greece by the tribes that penetrated there by following the chain of Pindus; but on the other hand, it is proved that the same very simple types of brooch are found both on the one hand in central Italy, and on the other at Mycenae, Olympia, Cyprus and Camisos. Is not the fact of that resemblance significant, one might almost say of that identity? Does it not give reason to think that the Dorians and the Italiots already possessed the brooch, when they started toward the South? Both carried it with them in their migrations, and during the longer or shorter time, they retained for it in their new residences the forms in which, they had received it from their fathers at the time of their departure. Central Europe would thus be the true native land of the brooch, the country of its origin.[2]

Note 2.p.249. Studniczo admits that the brooch originated in a region farther south than Greece, and that the latter received by the route of the Balkans, while other tribes coming from the same region as those that peopled the shores of the Egean sea, carried the brooch into Italy (p.19); but he believes that it already fastende the clothing of the Achaians, Eolians, and Ionians, that fled before the Dorian invaders. Since on the o

other hand, he does not find it at Mycenae, he concludes from this that the Mycenaean civilization is the civilization of the Achaians; but it does not appear possible to prove by the circumstances of discovery, for any of the brooches cited by Studniczo, that it dates before the Dorian invasion.

Everything accords in confirming this conjecture. If one goes back by the aid of funerary deposits into the history of that tribes that remained established on the Danube and its branches, one finds the brooch included in the equipment at their disposal. It is further easy to comprehend that the need of having recourse to it must make itself felt rather in the mountainous and cold region, that extends north of the Alps and the Balkans, than on the banks of the Nile or the Euphrates. In Egypt, Syria and Chaldea, among people of the lower class, the costume was frequently reduced to cotton drawers, that were retained by the projection of the hips; when it was complicated among the rich and the great, it again comprised only fine linen fabrics, wrapped around the bust, to which one sometimes added a woolen mantle thrown over the shoulders; but where winters were long and summers were late, where even in the fine season the temperature was changeable, clothing was required that was warm not only by the material of which it was made, skins of animals, felts of hair or fabrics of wool, but also by the firm connection of the different parts, a connection that according to the case could be made by sewing or by means of brooches, and the latter best lent themselves to allow the modification of the costume; with them one at pleasure gave it more looseness or drew it closer around the body. They were too convenient in use to be renounced, even when one could rigorously do without them; but as the taste for luxury awoke among the peoples that used the brooch, its forms were diversified, and they were charged with ornaments. There were brooches made of gold or of silver, ornamented by fine stones and round pieces of amber. Men tended to make of what had been at first only an instrument, a jewel more or less elegant, more or less richly decorated.

That tendency already manifested itself in a very sensible manner in the course of the period that occupies us. Henceforth, according to Homer, there were brooches where the precious metals entered into their fabrication, that which fastened the

garment of Ulysses was a jewel of great value.[1] The tombs ther yielded nothing of that kind, particularly in Greece; the brooches of that epoch that came from them are of iron bronze. Why these pieces are curious is, that the decorati there bears the very clear impression of the style, whose ments seem to have been introduced into Greece by the Dori and the tribes that accompanied them. Between the brooches the clay vases are closer relations than between those vas and the jewels of the treasure of Egina, or from the tombs the Dipylon. This is such, that when we sought to go back the origins of the style, that in Greece we have seen repl the Mycenaean style, we have been brought to ask ourselves it was not in the works of metal brought by the immigrants that the ceramic painter found the principle of the new sy of ornamentation, that he commenced to apply after the Dor invasion.[1] These objects are scarcely represented today in yield of the excavations made in the soil of Greece but on the brooch alone; that merits for this reason to be the ob of very particular attention.

Note 1.p.250. Histoire de l'Art. Vol. VII. p. 9, 232.

Note 1.p.251. The same. Vol. VII. p. 204.

For us the form of the brooch has le s importance than i decoration; then will suffice some bried indications on th subject. We shall occupy ourselves here only with types re sented in Greece. It is necessary to seek in special works lengthy nomenclature of the varieties, that they present a the most ancient inhabitants of Italy, Etruria, among the ans end in the Caucasus, at another extremity of the world own to the ancients.

The type that is regarded as the most ancient is charact zed by the arc and the tongue, also by the presence of a s le scroll; that is what we have found at Mycenae, and that also finds in the shore lands of upper Italy and in other of the peninsula.[2] The type that then comes in the probabl der of development is that termed a simple arch; it differ from the preceding by the semicircular form of the arc, th almost always decorated by parallel lines (Fig. 116). This appeared not only in all Italy and in the peninsula of the kans, but on the coast of Asia Minor end in the most ancie cemeteries of the Caucasus, particularly at Koban. The Gre

brooch is made more complicated in two ways. Sometimes the arc is decorated by enlargements or beads (Fig. 117); sometimes the plate is enlarged and receives line engravings. These brooches with large engraved plates are scarcely found except here in Greece (Fig. 118).

A form that especially belongs to Italy is tha of a brooch in the form of a boat, also termed the form of a leech; it is characterized by the very strong middle enlargement of the arc, which is sometimes hollow inside. Some examples are also found in Greece; such have been met with at Olympia and Dodona (Fig. 119). In a variety of this type the arc is decorated by lateral projections, sometimes by figures of birds (Fig. 120). That is the case of a brooch from Kamiros, that we have already published, and that would have been bette in its place.[1] There is finally the brooch whose arc is decorated by a double series of spirals, a type mentioned in Greece, Italy and North of the Alps. (Fig. 121).[2]

Note 1.p.252. Histoire de l'Art. Vol. III. Fig. 584.

Note 2.p.252. Böhlau in Jahrbuch. 1888. p. 382.

Among these brooches, there are some where the geometrical ornament appears in its most primitive simplicity under the form of spirals coiled on themselves, grooves and parallel bars, or chevrons and concentric circles. (Fig. 122). Elsewhere appears inscribed in a circle (Fig. 123) or isolated (Fig. 124) that star composed of four leaves in cross shape, that we have found on the vases. The leaves, if it be proper to give them this name, only occasionally resemble true natural leaves; then are absolutely regular. Here as on painted pottery, the first image of a living being that comes to vary the monotony of this decoration is that of the duck. One finds it on the brooches of very archaic manufacturr in Italy as in Greece, either sculptured in relief or engraved, sometimes beside motives purely l linear (Fig. 124), sometimes with men or large quadrupeds (Fig. 118); it also is on the brooches with broad incised plates, in that evidence an art more advanced. These are particularly curious; one finds there the same subjects as on the vases of the Dipylon or analogous subjects. The character of the drawing is entirely similar. The arc is there formed by three or four juxtaposed shells, the last of which is connected to a strong and slightly curved stem parallel to the plate. From the other end

of this plate starts the head of the pin, which is connected by a double spiral spring (Fig. 125). One of the plates has three fishes for the decoration of one side (Fig. 126), and for the other a fylfot cross (Fig. 127), motives of which the ceramic painter made frequent use. On another brooch of the same type, the themes are more complex. One of the faces represents a horse with lowered head, as if feeding; below is a star and a bird, a goose with wings extended (Fig. 128). On the reverse is a ship, above which on each side of the mast are represented two birds placed symmetrically. Beneath the broken line of the waves two fishes swim to the right. (Fig. 129). The combination of these two motives, the horse and the ship, on the two faces of the same plate is not rare, and more than one vase has presented to us the type of the grazing horse and that of the ship under sail, with the fish or the bird as filling. (Figs. 48, 49). On one of the faces of the third brooch is the scene of a combat. Two warriors are fighting, and between the two is a small personage clad in a robe, doubtless a woman, that makes gestures and lamentations. (Fig. 130). We have already found this duel on the vases, as well as the same helmet and the same round shield (Figs. 58, 63, 67).

The subject figured on the reverse of the plate was not yet shown on either in ceramics or on bronze. In the left angle of the panel is engraved a star; in the right angle is a segment of a radiating disk. On the field two persons stand in an attitude of adoration. They are clothed in robes whose ornaments are indicated by lines forming lozenges. The two persons of indeterminate sex face each other in a heraldic attitude, each raising an arm, their hands joining on a stem charged with leaves, that they seem to touch with a gesture of respect. Beneath the stem is a disk surrounded by a zigzag decoration representing rays (Fig. 131).

One cannot doubt the meaning of this scene; the Beotian engraver has awkwardly represented a theme, that is one of the commonplaces of oriental art, and not ignored by Mycenaean glyptics, the adoration of the tree or sacred plant;[1] the presence of the stars in the field fully reveals the origin of the theme. We have also seen appear on the more recent vases of the Dipylon certain motives, unskilfully borrowed from Phoenician wares, where nothing connects them with what surrounds them;

(Figs. 66, 96, 97); they announce the influence that foreign models will soon exert on the Greek artist.

Note 1.p.255. Histoire de l'Art. Vol. VI. Figs. 428-18).

Another brooch from the same source presents with a curious variation, several motives that we have already met with (Fig. 132). The horse is surrounded by birds and quatrefoils, and is accompanied by her colt.

Not alone by the choice of motives does the decoration of th these brooches appear contemporaneous with that of the antique pottery, but also by the analogy of the style. On the plates is the same angular drawing as on the vases, the same unnatural reduction of the waist above the hips, the same elongation of the entire figure, the same projection of the calves. This thinness of the body, that contrasts with the breadth given to the muscles of the thigh, is found in the horse. It is the same procedure in the drawing, the artist does not fail in seizing the characteristic traits of the different types that he reproduces; but when he desires to render them, he exaggerates and deforms them.

The most ancient and simplest brooches, as well as other works of the same kind in metal, in our opinion, must have contributed to suggest to the ceramic painter the idea of the decoration that admits no element borrowed from the world of life; but the brooches with ornamented plates no longer belong to that first age. Those of known source were found with vases and other objects of a style already advanced.[1] We have seen what place the figure held; now there is no trace of that in the monuments, where we have sought outside Greece the prototypes of the rectilineal geometrical style. Finally, what are significant are the motives of Aryan origin that make their appearance here. When the engraving of these plates had been executed, the same style, that tended to emancipate and extend itself, prevailed both in the workshops of the ceramist and of the bronze-worker.

Note 1.p.258. According to Böhlau, the great brooch of the museum of Berlin (Fig. 119) came from a Beotian tomb, which d dated at nearly the same times as the tombs, where were found vases that we regard as already no longer belonging to the period, whose history we have just written.(Jahrb. 1888, p. 362).

This style is that of a beautiful tripod that we have already shown with the bronze urn for which it served as support (Fig.

(Fig. 2); but to appreciate the elegant and careful execution, it is necessary to see it entirely separated from the upper part.(Fig. 133). Each of the three legs is made of a band of metal decorated by herring-bone ornament, which is found on one of the bone plates from the same source, that served as facings of wooden coffers. At the top of each leg is a double so spiral wall, that recalls the volutes of the Ionic column. The crown resting on these legs is perforated; between two half ro rounds extend spirals joined together. The whole is in happy combination and proportions; by the appearance of the work one divines that this kind of furniture was then of current fabrication; it must have been much used as a support, almost everywhere in the house and in the temple. Its image appears very frequently repeated on the vases of the Dipylon (Fig. 8).

As for the arms, we have indicated what character must be pr presented by certain arms of luxury described by the epic poet; we have seen either these waifs from the wreck of Mycenaean civilization or the products of Phoenician industry. The excavations have yielded nothing, that even distantly recalls those masterpieces of the goldsmith or of the armorer. Judging then by the specimens that have been found in the tombs of the Dipylon, the arms in the 9 th and 8 th centuries would have been very simple. Then an accomplished fact is the substitution of iron for bronze; near the skeletons of the warriors one then finds only swords, spear heads and axes of iron. Nothing indicates that these arms may have had rich mountings, that the guard or the handle may have been covered by precious metals, ivory or even carved bone. As for the forms, they are almost identical with those of the preceding age.[1] An iron sword, whose point is lacking, in its present condition is 18.9 ins. long by 2.36 ins., where the blade is widest (Fig. 134). There are blades of daggers of the same metal and two types of axes. Some are rectangular; they terminate in a shank that fits in a wooden handle (Fig. 136). Others have two edges; at its middle the iron is pierced by a hole into which is fixed the handle of the weapon (Fig. 137).

Note 1.p.257. Dümmler. Zur Nekropole am Dipylon und dem Styl der Dipylonvasen. (Athen. Mitt. 1888. p. 294-308). Brückner and Pernice. Ein attischer Friedhof. (Athen. Mitt. 1893.p.107-108).

Not the least fragment of shield or helmet, no trace in the

tombs. If one can hope to fill that lack, it is by the comparative study of the information on the subject furnished by the epic poems, and by that derived from the images of warriors, that ornament many works of the seramist and of the goldsmith. The conclusion reached in that way can be formulated thus; the defensive armor that the poet attributes to his hero is also that represented by the vases of the Dipylon, and it does not sensibly differ from that in use in the course of the preceding period. Not without surprise does one verify the long persistence of a very primitive mode of arms, that while ensuring to the body of the soldier only a very imperfect protection, requires an extraordinary display of strength and suppleness. Yet force is in evidence; the researches of several scientists have have already led men to suspect that truth, but it has been placed beyond doubt by the critical labors of Wolfgang Reichel.[1] During a sojourn of two years in Greece, he examined one by one even to the least remains of Mycenaean antiquities in the museum of Athens, and made a complete catalogue of them. These monuments emphasized to him the true senses of the verses, that were often badly understood by the ancient commentators, who lacked the knowledge of things of the distant past. Thus he arrived at forming an idea of the nature, form and use of arms that the poet assigns to his heros. See in wha terms in the beginning of his Memoir, he summarizes that long investigation, that he conducted with rare sagacity.

Note 1.p.258. W. Reichel. Ueber homerische Waffen, archaeologische Untersuchungen, mit 55 Abbildungen im Texte. 8. 152. Vienna. 1894. The views of Reichel are accepted in general by one of the men best knowing Mycenaean antiquities, Maximilian Mayer (Berlin phil. Woch. 1895, Nos. 16, 17); he only makes r reserves in certain details. Solomon Reinach also shares the same opinion. (See his Article in the Dictionary of Daremberg and Saglio).

"The chief part of the defensive armor in the epic age is the great shield, that shelters the person of the combatant, which we have learned to know from the Mycenaean monuments. The warrior's body was covered by this shield from the top of the chest to the knees. He carried it by means of a strap that rested on the left shoulder; by the aid of that strap and a crossbar placed behind the protection, he moved and handled it. By reason

of its particular form, it was not only in front that this shield protected him, who was equipped with it; his sides were also defended more or less effectively. Thus the shield in some fashion performed the function of the cuirass. In the proper sense of the word, the cuirass only appears in the most recent parts of the Homeric poems. Much before it came into use, the "mitre" already ensured to the abdomen the protection of a plate of metal directly applied to the trunk. The "zoster" or leather belt also plays the same part in a certain measure; but it especially raised the tunic in a manner, so that in battle it did not restrict the movements of the body. No more than the cuirass, did the heros of the epic poem yet know the metal greaves, that later enclosed the shin and knee of the Greek hoplite; their invention is much later. What they wore were half boots of leather or cloth, with sufficiently high legs; they were necessary to prevent the bones of the leg from being hurt or bruised by the lower edge of the great shield. Men did not yet use a helmet with visor to cover the head; what took the place of that was a helmet in form of a bonnet or skull cap, that protected the top of the head; it was more frequently made of leather than of metal."[1]

Note 1.p.259. Reichel. Ueber homerische Waffen.

In what concerns the shield, the monumental tradition accords with the statements of the two poems. On the vases of the Dipylon that appear most ancient, one finds that a single shield, which the painter equally gives to the foot soldier, to the drivers of chariots and even to the rowers, who in danger of arrows propel the ships of war. (Figs. 7, 63, 66, 67). This is indeed still the Mycenaean shield; like that, the shield of the vases is very high and very broad. Leaving both hands free, one divines that it was carried by being suspended from the neck by a strap; it covers the entire bust from the shoulders to the bottom of the thighs. What caracterizes it is, that the lateral notches here appear much deeper; but that difference is perhaps less due to even the form of the model than to the procedure of the draftsman. To make more apparent the effect of the doubled notches, he exaggerates their depth, as he does the projection of the muscles of the calf and the arm.

About the end of that period, probably in the second half of the 9 th century, a change is produced as shown by the painting.

The begin to use a round and smaller shield attached to the left arm by a handle (Fig. 58). On a fragment that came from Athens, there are for three warriors as many different shields, two of which reproduce the two typical varieties of the Mycenaean arm, while the third is already that of the Greek hoplite. (Fig. 138). One reaches the moment when that hoplite is completely armed and makes his appearance in sculpture. From the first years of the 7 th century appear to date the oldest of the vases, on which this type is shown with the very particular traits, that will not cease to characterize it thenceforth.[1] As for the cuirass, it is not drawn on the ceramic works of the Dipylon. Greaves are often indicated on the monuments of Mycenaean sculpture and of painting;[2] if one does not find them on the personages that decorate the vases of Athens, this is because there the entire body is detached in black, from the ground, and there is no place for indications of that nature.

Note 1.p.260. For example on the beautiful vase from Melos belonging to the museum of Athens, and which was formerly published by A. Conze. (Melische Thongefosse. Pl. III).

Note 2.p.260. Histoire de l'Art. Vol. VI. Figs. 369, 370, 439; Ephemeris. 1887. Pl. XI; 1891. Pl. III-2.

The Homeric helmet is that which we have found at Mycenae, Tiryns, Menidi and Spata on statuettes of bronze, ivory busts, engraved stones, vases of clay or of metal.[1] Whether the helmet be furnished with a plume or crest, it is only a sort of skull cap or conical bonnet (Figs. 139, 140). It has neither cheek nor nose pieces, or visor; it always leaves the face uncovered. In the paintings of Attic vases, the helmet only reveals its presence by the plume surmounting it; in the contour the head-dress is confused with the head on which it is placed (Figs. 7, 58, 67, 98). Yet here is a fragment on which the details are very clearly distinguished (Fig. 141). Provided with a crest, the helmet seems to descend very low on the brow and the nape; one asks if it be not already provided with a nose-piece. The profile is already almost that of the helmet with visor; one feels himself in the period of transition between the old and new equipment.

Note 1.p.261. Histoire de l'Art. Vol. VI. Figs. 353, 354, 355, 365, 421, 428[6]).

The conclusion suggested by these remarks has been already

divined. The defensive arms that the artists of the 6 th and 5 th centuries gave to the heros of the Iliad and of the Odyssey in the paintings of their vases, differ greatly from those borne by the ancestors and contemporaries of the epic singers. In their manner, these artists were as far from historical truth as Flaxman has been among moderns, when in compositions that were for a moment in vogue, he represented the same heros of the epic poems as going naked to the combat. The warriors that the epic poets had under their eyes, and which they placed in the scenes, were not those of the "men of brass,"[2] Ionians and Carians, who will give Psammeticus the empire of Egypt. Their equipment was still that used by the men of the preceding age, which in fact was but one important piece, the great hollow shield almost as high as the body, all the rest, greaves and a helmet of leather more or less covered by metal, the bronze belt, playing only a very secondary part in the work of protection. During two or three centuries after the Dorian invasion, the Grecian world was too much agitated, too profoundly troubled for it to change much in the arts of war as in those of peace; men rather lived on the legacies of the past. Later, when the later ethnic elements were mingled with the ancient ones, and there was created a new Greece, an industrious producer and adventurous colonizer, the genius of invention awoke, and to put itself in condition to contest with advantage against peoples, who had over them the superiority of numbers, the Ionians first adopted the armor and greaves, cuirass, shield and bronze helmet. Did the Ionians borrow these new arms from the Carians, as ancient tradition affirms?[1] It matters little; one can be certain, that if the Greeks of Asia Minor derived from their neighbors the principle of the new equipment, according to their habit they have failed to modify and perfect the arrangement and use of the pieces composing the armor. Their example was always followed soon; but the use of that armor began to extend only about the end of the 8 th century at earliest; it did not become general and the regular equipment, the distinctive mark of the Grecian hoplite till in the course of the 7 th century. It is then to confound the epochs and commit an anachronism to attribute it to the hero of the epic poem.

Note 1.p.262. Herodotus. I, 171; Strabo. XIV. 2-27; Plutarch. Artaxerxes. 10.

Also the technics of metallurgy appear to have remained stationary during this period; there was even a loss of certain secrets of the trade. By means of little rivets, the Mycenaean goldsmith fastened together the pieces of silver, copper and bronze, that composed his works; but he knew how to solder gold on gold.[2] On the contrary, in the jewels contemporaneous with the vases of the Dipylon offered no trace of soldering, and Homer nowhere alludes to that process. nails of gold or silver always serve to fasten the metal on sceptres, on hilts and sheaths of swords, and on seats. The thrones of the gods are ornamented by overlays attached to the wood by nails of silver.

Note 2.p.282. Histoire de l'Art. Vol. VI. p. 590, 973-974.

Held in place in the same manner, ivory entered into the facing of seats, doors, keys, and doubtless of arms also.[1] It supplies the poet with comparisons; its color and appearance were familiar to his contemporaries.[2] Ivory was found in the tombs of the Dipylon (Figs. 21-25); but it was not found there in quantities comparable to what has been furnished by certain tombs of the preceding age.[3]

Note 1.p.283. Odyssey. XIX. 55, 563; XXI. 7.

Note 2.p.283. Iliad. IV. 141-145. Odyssey. XVIII. 197.

Note 3.p.283. Histoire de l'Art. Vol. VI. p. 414.

At Athens it is frequently replaced by bone, that was of less cost; of bone were made most of those carved plates collected in the excavations of the Ceramicos, the represent there the equipment of caskets and coffers formerly buried with the dead.

As for amber, that the Italiots and other peoples of the West so greatly prized, when the tastes of the Greeks were once formed, they do not appear to have made much use of it; its semi-transparency did not lend itself much more than glass to give the contour that clarity always so dear to them. The mention of it is believed to be found in two passages where the poet describes necklaces;[4] but it is to be noted, that at least one of those jewels is given as the work of a phoenician jeweler. So far as I know, no amber has been found in the excavations of the cemetery of the Dipylon.

Note 4.p.283. Odyssey. XV, 460; XVIII, 295; Helbig. L'epopee. p. 342-343.

3. Fabrics and Clothing.

If in what concerns armor and the mode of fighting, the Homeric age continues during at least a long time the tradition of the Mycenaean age, it shows itself in other respects a bolder innovator. The tribes of the North brought it the brooch; the facilities afforded to it by the use of that fastening suggest for clothing arrangements, that would not have been possible without it.

We canno think of studying separately and explaining, as done elsewhere with much care and criticism, all the terms that in Homer designate the different fabrics and parts of the costumes of man and women.[5] All that we propose here is to define by some precise traits the taste, and what one may term t the spirit of the Homeric vestments.

Note 5.p.283. Studniczo. Beitrage zur Geschichte der altgriechen Tract. Vienna. 1886. p. 143 + 47 figs in text; Helbig. L'epopee homerique. Chapters 11-15.

Henceforth the Greeks were acquainted with fabrics of both l linen and of wool. The name of linen is found in Homer.[1] Further, the epithets that the poet has attached to many parts of t the costume, that imply a light tissue of uniform and smooth appearance, have meaning only if they apply to cloth. Cloth a alone can assume by bleaching and preparation that lustre, which seems to have been so much appreciated.[2] It was not otherwise by all the fashions that it received. There is reason to believe, that in certain cases it was plaited artificially by processes analogous to those, that today the Athenian peasant still employs for obtaining the gathers of his kilt. By the monuments of Egypt, Chaldea and Syria, we have the proof that the orientals liked thus to goffer cloth.[3] If the Greeks borrowed from them the use and even the name of tunic,[4] they must have taken from them at the same time the taste for this goffering. A fabric submitted to this manipulation is designated by the expression of "twisted tunic;" a prolonged twisting is one of the means employed thus to plait the cloth.

Note 1.p.284. Iliad, II, 529, 830; IX, 661; Odyssey, XIII. 73, 118.

Note 2.p.284. Iliad, XXII, 508-511; Odyssey, V, 230-231. Fabrics are compared to the sun (Iliad, XIV, 185; Odyssey, XIX, 232). The epithets "shining, shining like oil, and white," or-

arouse the same idea.

Note 3.p.264. Histoire de l'Art. Vol. I. Figs. 433, 434, 435, 462, 468, etc.; Vol. II, Figs. mel, 290, 296; Vol. III, Figs. 283, 302, 318.

Note 4.p.264. The same. Vol. VI. p. 490.

As for wool, preparing and weaving it was one of the principl occupations of the numerous female servants, that formed a part of every well kept house.[5] There were made of it rugs,[6] coverings of beds,[7] and mantles.[8] Wool also furnished the material of other parts of the clothing, for example of the peplos.

Note 5.p.264. Iliad. V. 113; XXI, 30-31.

Note 6.p.264. Iliad, III, 387-388; Odyssey, XVIII, 316; XXII, 343.

Note 7.p. 264. Odyssey, IV, 124.

Note 8.p.264. The same. I, 443.

The ordinary costume of men consisted of two pieces, the tunic (chiton) and a mantle most frequently termed "chlaina,"[9] but which also sometimes bears the name of "pharos". The verbs employed by the epic poets to indicate the act of putting on the tunic, give reason to think that this was a vestment that one put on as we do the shirt;[10] truly speaking, it was a shirt without sleeves. This vestment was of linen; and the Hebrew word from which "chiton" is derived is connected with the same root, and belogs to the same family as the words, which designate l linen and flax in several Semetic languages.[1] Epithets qualifying the tunic are further those, that only seem to us applicable to linen. Nowhere is there mention of a tunic ornamented by designs; all indicates that the chiton comprised no luxury other than the lightness of the tissue and the whiteness of t freshly washed cloth.

Note 9.p.264. Iliad, X, 133; XXIV, 646; Odyssey, IV, 50, 299, etc. The ordinary epithet of the chlaina is shaggy.

Note 10.p.264. Iliad; XVIII, 416; XXIII, 739; Odyssey, XV, 60, etc.

Note 1.p.265. Helbig. L'epopee, p. 205.

The length of the tunic varied with the occupations and the parts of those clothed with it. Various passages of the two po poems cause it to be understood, that warriors were clad in a tunic that did not even descend to the knee, while others imply one that falls to the feet and even drags on the heels.[2] To the

latter relates the epithet "draggers of tunics," which is given to the Ionians, both by the Iliad and by the hymn of the Delian Apollo.[2] It is probable that men distinguished thenceforth the short chiton, a vestment for combat, hunting and labor, and the long chiton, one of peace and ceremony; the latter was the costume of old men, kings and most of the gods. The belt is often mentioned in the epic poems as one of the elements necessary to the feminine costume, but is there mentioned only twice in reference to men.[4] Perhaps on errs in concluding from this that for men the tunic was worn without a belt.[5] I shall explain this silence otherwise. Among women the girdle was placed over rich fabrics and was an object of ornamentation. For men being attached to the tunic without decoration, it was often only a cord, a band of cloth or of leather.[6] That use is supposed by the expression, "to gird himself." When one prepared to fight or to run, he drew up the bottom of his tunicl and to f free his legs, kept it there by the pressure of a cord.[7]

Note 2.p.265. Helbig. L'epopee, p. 205.

Note 3.p.265. Iliad, XIII, 685; Hymns, I, 147.

Note 4.p.265. Odyssey, XIV, 72; Iliad, X, 77.

Note 5.p.265. Helbig. L'epopee. 218-219.

Note 6.p.265. Yet the belt of Nestor is called party-colored.

Note 7.p.265. Iliad, XI, 15.

Men wore the tunic alone only in the house, or when engaged in violent exercise. To go out, they cast the mantle over the shoulders.[8] The mantle was of variable dimensions; there was the simple mantle and which was sufficiently ample, so that if one did not have to cover the entire body, it was folded, thus doubling the cloth.[1] As a difference from the tunic, the mantle was fastened at the neck by a brooch.[2] The wool was dyed a color; red and purple were preferred.[3] The fabric was often ornamented by designs, whose character is not clearly defined by the poet.[4] These ornaments were sometimes figures. On a "diplax" of its shape, Helen had represented the combats between Trojans and Achaians.[5] This could only be embroidered with the needle.

Note 1.p.266. Iliad, XXIV, 229; X, 134; III, 126; XXII, 440.

Note 2.p.266. Iliad, X, 133; Odyssey, XIX, 226.

Note 3.p.266. Iliad, X, 133; Odyssey, XIV, 500; IV, 115, 154; XIX, 225.

Note ..p.266. There is no agreement concerning the meaning of

the expression that the poet employs with reference to a diplox with a ground of purple, whereon Andromache has scattered ornaments. (Iliad, XXII, 440). Hesychius and the scholiasts explain "throna" by "anthe". Perhaps it refers to rosettes and palm leaves.

Note 5.p.265. Iliad, III, 125.

The mantle was worn by everybody indifferently, and men of hi high or low condition. The pharos was the mantel of kings. It must be much larger, for it usually received the epithet of great, which is never applied to the mantle.[6] There is reason to believe that the pharos was of linen; the poets designate by this term not only this mantle of men,[7] but also different pieces of cloth, such as swaddling bands, shrouds and the sails of ships,[9] which can only have been made of threads. At least then less as a defense against cold, than as a vestment of luxury and state, frequently of a beautiful tone of purple.[10]

Note 6.p.266. Iliad, II, 43; VIII, 221; Odyssey, VIII, 84.

Note 7.p.266. Hymns. I, 121.

Note 8.p.266. Odyssey, II, 93-99; XIX, 138-145.

Note 9.p.266. Odyssey, V, 258.

Note 10.p.266. Iliad, VIII, 221; Odyssey, VIII, 84.

The skin of an animal at need replaced the mantle. Warriors wore the skins of a lion, panther or wolf; shepherds and peasants, skins of a stag, sheep or goat.[11]

Note 11.p.266. Iliad, III, 17; X, 23, 29, 177, 234; Odyssey, XIII, 436; XIX, 23.

The principal vestment of the woman was called in the epic poems "heanos" or "peplos"; the two words appear synonomous. This vestment was placed directly on the skin, this clearly results from several passages in which it is mentioned. When Hera thinks of fascinating Zeus, she washes her entire body with ambrosia and bathes it with perfumes. Then she is nude. After completing these preparations, she puts on the beautiful heanos presented to her by Athena; she fastens it with brooches at the height of the chest; then she buckles the girdle below.[1] No tunic, the heanos of soft tissue is applied on this divine body, which she has thus prepared to surprise and charm her spouse. When Pallas, before arming for the combat, drops to the ground her peplos to put on the tunic of Zeus, it is evident that the garment removed, corresponds in the feminine costume

to the tunic of the men.[2]

Note 1.p.267. Iliad, XIV, 170-181.

Note 2.p.267. The same. V, 230; VIII, 385.

The heanos and the peplos descend to the feet, as sufficiently indicated by the epithet "who trails her peplos," the use of which is very frequent. It was fashioned the bust by brooches; on the peplos that one of the suitors presented to Penelope w were 12 brooches of gold. Finally, the peplos was most frequently colored, yellow like saffron, dark blue, red like fire.[3] Designs more or less complex are detached in another tone from the vivid tints of these grounds;[4] thus the peplos is often o qualified by party-colored.[5] Now the color does not take so m readily on linen as on wool. Then where polychrome fabrics are mentioned in those distant times, there is every chance, that those are of woolen cloth. On the contrary, if it concerns linen, there is an entirely different series of epithets, that o one meets with, adjectives that boast of the whiteness of the fabric.

Note 3.p.267. Iliad, VIII, 1; Hymns, V, 182-183; IV, 86.

Note 4.p.267. The same. XIV, 178.

Note 5.p.267. The same, V, 735; Odyssey, VIII, 283; Iliad, VI, 289; Odyssey, XV, 105. See Iliad, VI, 294; Odyssey, XV,107.

By the part it plays, by its mode of fastening and the material of which it is made, the Homeric peplos is then that with which were clothed, some centuries later, the women that served as models for Polycletes and Phidias. This was a vestment without seam and made of a rectangular piece of cloth doubled in the direction of its greatest dimension. The two edges are connected together above the shoulder and at the side by a series of brooches of unequal widths, and these allow the arms to pass at the top, which thus appear naked in their entire length, from which is the epithet "with white arms." Below the knee are more brooches that close the gap. In the movement of the step, the edges of the fabric separate and show the bottom of the leg. Several epithets allude to the beauty of the ankle.

As we have stated, the pharos was a linen tissue more flexible and more brilliant than any other. To kings, it is attributed by the epic poets to goddesses. In the pharos were wratted Calypso and Circe on leaving the bed.[1]

Note 1.p.268. Odyssey, V, 230; X, 543.

Over the heanos, the peplos or the pharos, the woman places a belt in dressing, which gathers this drapery around the waist. Sometimes it is of gold, i.e., formed of plates of metal laid on a band of leather,[2] and sometimes is ornamented by numerous fringes.[3] Those fringes must be tufts made of gold threads or of very thin sheets of the same metal, as found in a tomb at Mycenae (Fig. 192). It is probable that this ornament was of oriental origin; one sees those tufts hang from the belts of certain personages in the Assyrian reliefs.[4] The epithets "bathyzonas", euzonos and challizonos" indicate what importance was attached to the presence of the belt. Did the two last refer to the manner in which was arranged the belt or the more or less rich material composing it? It is difficult to say. As for bathyzonos, an explanation of it is given that is confirmed by the monuments.[5] This alludes to the very deep hollow that is made in the falling drapery by the very tight belt around the waist. The more marked is that hollow, the more slender seems the waist. The true translation of bathyzonos would then be; remarkable By the slenderness of the waist. We have stated the insistence with which the Mycenaean artist emphasized by exaggerating the reduction that the trunk shows above the hips.[1] A slender stature was then certainly regarded as a beauty. It continued to be so during the following age. That is what the poet had in view when he said, that Agamemnon had the head and eyes of Zeus, who pleased to launch the lightning, the length of the belt of Ares and the breast of Poseidon.[2] The same tendency is very apparent in the paintings of the vases of the Dipylon. Their proportions are much elongated; the peculiarity of form that we have indicated are found everywhere, among the men as well as the women. In female figures the compression produced by the belt contributed much to accent the effect of thinness sought by the designer.

Note 2.p.268. Odyssey, V, 232; X, 543.

Note 3.p.268. Iliad, XIV, 581.

Note 4.p.268. Histoire de l'Art. Vol. II, Fig. 205.

Note 5.p.268. Studniczo. Beiträge. p. 120-121.

Note 1.p.269. Histoire de l'Art. Vol. VI, p. 873.

Note 2.p.269. Iliad, II, 478-479.

If the heanos, peplos and pharos were undergarments like the tunic for men, the feminine costume further comprised a great

veil, that the epic poets call "chredemnon or chredemna, chalyptre and chalymma." The species of shawl designated by these three terms was usually placed on the back of the head, leaving the face uncovered, and hung on the back and shoulders.[3] One sees it worn thus on a relief of Sparta, that is one of the mo most ancient monuments of Greek sculpture (Fig. 143). The women only cover the face when they desire to remain unknown, or to separate themselves from the world when mourning.[4] When women converse with men, the rules of propriety required them to half conceal the face wit the hand, the veil drawn on one cheek. That is the attitude that the Odyssey gives to Penelope when she shows herself to the suitors;[1] it is frequently represented in the archaic monuments. Coquetry lost nothing thus. That gesture by placing half the face in shadow only made the value of the rest greater, and gave a most graceful movement to the arms.

Note 4.p.269. Hymns, IV, 197.

Note 1.p.270. Odyssey, I, 334; XVI, 416 etc.

The headdress on which was placed this shawl was quite complicated, at least for women of high rank. What best gives the idea are the verses in which Homer relates how Andromache, when she learns the death of Hector, tears off all that she has on her head, to leave her flowing hair falling down her back. (Greek poem).

Note 2.p.270. Iliad, XXII, 468-470.

What Homer calls "gleaming ties" is the entirety of that headdress, where the gleam of the metal mingles with the vivid and varied colors of the fabric. The "ampyx" is a metal diadem similar to that, which in another part of the Iliad is termed "stephane" or crown.[3] the "credemnon" is the veil falling down on the nape; but what must be understood by the "kekryphalos" and by the "plecte anadesme?"

Note 3.p.270. Iliad, XVIII, 597.

Lexicographers do not give a precise definition of the "kekryphalos," and for a stronger reason they know nothing of the "anadesme." In the paintings of Etruria is found the mode of adjustment by which is best explained the mien and pose of Andromache, and the various terms grouped here by the poet.[4] th There are frequently seen women covered by a high and stiff bonnet, that entirely covers the head and only allows to be seen a narrow band of hair along the brow; it terminates behind

by a back much raised. On the front that headdress is sometimes enclosed by a metal diadem, the ampy (Fig. 144). Further, at the same place are one or several bands of cloth, and higher at the top of the head is a sort of cushion or fringe, which is both an ornament and a band (Fig. 145); the band is intended to fix in place the bonnet, which has no strings. A bonnet of the same kind and attached in the same manner was worn by the Ionian women, at least in certain districts. This arrangement was not in use everywhere; no mention of the kekryphalos is made in the very detailed description of the toilette of H Hera;[1] the goddess appears to place the "kredemnon" itself on the head over the hair. The mourning of Andromache furnished t the poet with the occasion for recalling to his hearers the singularity of some local fashions and we should have to recognize in the fringe of the Etruscan monuments the plaited band. This fringe is placed on an elevated point of the headdress, which seems indicated by one of the elements, that enter into the composition of that substantive, by the preposition ana. Some have desired to see in the anadesme a ribbon, that is knotted in the tresses arranged as a chignon or in plaits. If t this were so, considerable time would have been required to loosen the knots. On the contrary, with the interpretation that we adopt, nothing is easier to understand than the movement of Andromache. Her hand roughly tears off the veil, diadem, fringe and the bonnet that it retains. Under the act of her curved fingers, all is removed at once and falls to the ground.

Note 1.p.271. Iliad. XIV, 170-180.

Note 2.p.271. See the texts collected and commented on by H Helbig. L'epopee, p. 298-299..

There is something of the same research in the headdress of the man. A number of verses in the epic poets attest, that the epic period and Ionians of that time wore very long hair.[2] If this hair flowed freely over the shoulders, at least in certain tribes it was held by metal clasps. In reference to the Trojan Euphorbos, the Iliad speaks of his "curls retained by gold and silver."[3] What held those locks were spirals, made of metal wire in several turns, spirals of which numerous turns are found at Troy, in the tombs of Mycenae, in Beotia (Fig. 146), at Olympia and in Etruria. As for the beard, it seems to have been worn around the neck and long beneath the chin; with the upper

lip shaved as in the Mycenaean age.[1] The use of the razor was much extended,[2] and when Athena restores to Ulysses, transformed into a mendicant, his beauty as a hero, on his chin is developed a beard of a bluish-black.[3] Always is mention of the chin, when the poet speaks of the beard that grows or whitens; never is any allusion made to the moustache, for which the Homeric language has no name.

Note 1.p.272. Histoire de l'Art. Vol. VI, p. 812, Fig. 381.

Note 2.p.272. Iliad. X, 173.

Note 3.p.272. Odyssey. XVI, 175-176.

From all the preceding observations it results that the Homeric costumes already is no longer the costume of primitive Greece. That seems to have presented two different forms for men. In the tombs of Mycenae have been found in thousands leaves and rounds of gold, that must have been sewn on pieces of cloth. These overlays could have been placed only on very ample garments, that covered the entire body, on vestments like long robes and falling to the feet, in which several personages are dressed in intaglios of the Mycenaean epoch; but those are kings or priests that these images seem to represent, which are further quite rare.[4] The number is very much greater, where nudity is almost complete, or the clothing is reduced to a sort of drawers. Those are ordinary figures, hunters and warriors in sculpture and glyptics.[1] Now that extreme simplicity of costume, which does not seem to suit the climate of Greece, does not one divine a remnant of the habits of an almost savage life, at least as a memory of the time before the industry was sufficiently developed, the body was hardened by long custom to bear storms, and rays of a burning sun in summer, with the rigors of the north wind in winter?[2]

Note 4.p.272. Histoire de l'Art. Vol. VI. Fig. 431,[4] pl. XVI,18.

Note 1.p.273. The same. Pl. XVIII, 1; Figs. 353, 355, 358, 362, 370, 421, 422, 428,[1] 426,[11,21] 431.[2]

Note 2.p.273. There is only one Mycenaean monument on which one can see the tunic; this is the vase that represents a file of warriors (Histoire de l'Art. Vol. VI, Fig. 497); it is worn by a woman; but is this vase really of the Mycenaean age? Would it not be rather contemporaneous with protoattic vases, with which it presents singular analogies? (Pottier. Rev. Arch. 1896-1897, p. 19-23)? The doubt remains, even after the discovery of

the curious fragment of a mural painting of Mycenae, published by Tsoundas. (Ephemeris, 1896, Pl. I).

In the time of Homer, the use of the tunic had become general; thenceforth among the Greeks it is the essential part of the masculine costume, and what does not seem debatable, considering the origin of the word chiton, is that the change was caused by the effect of relations made with the Semites. Seeing such a convenient garment on the backs of Syrian merchants, the Greeks learned to appreciate its advantages; to borrow it from them was a first advance. What remained to do was to give the tunic an elegance, that it could not retain in the thin and dry folds of linen. The classical age will provide for that by substituting wool for linen in making that shirt, and by skilfully utilizing the belt so as to make the fabric exposed and to arrange its folds.

It is impossible for men of the Mycenaean age not to have had some hing resembling the cloak; but then this must have been most frequently only the skin of an animal, and had no form peculiar to it and consecrated by custom. That special form possessed among the Ionians, among whom the epic poets lived; it was called chlaina. How does the chlaina differ from the classical himation? The reply to that question is, that it is not to be asked from the monuments; we have none to cite contemporaneous with the epic period, and when art might be sufficiently advanced that the movement of the drapery was clearly indicated. Still one sees from certain words of the poet, that there was a difference.

As a general rule, the himation had no other ornament than a border, where the motive of the design was very simple, and that showed by its color on the dead white of the woolen; accordingly it lent itself to all a rangements. On the contrary, the chlaina was ornamented by rich and varied designs, an ornamentation that it was desired to show. If Helen embroidered a battle scene on a diplax, this was not to conceal it under the folds of the cloth. There i only one place where the picture traced by her needle could be well in view; that is the broad field formed by the cloth on the back, provided that it fell straight. Thus one was led to a symmetrical arrangement of the mantle, placed vertically over the two shoulders like a chasuble, and perhaps no other was known, while later there

would be many different ways of clothing one's self in the himation, fashions that change wit the age of the individuals, with their social position, and with the occupation to which t they were devoted.

The same observation is for the feminine costume. It differs very sensibly from that known to us by the figured monuments of the Achaian age' the adoption of the brooch changed its character. The peplos of the heroines of the epic poems plans the same part as that of the Athenian women of the 5 th century; there is the same cut and the same fastenings, but as indicated by the epithet bathyzonos, it is drawn closes above the hips, that suppresses or reduces the folds in the upper part of the garment. Besides, like the chlaina, the Homeric peplos is tinged with vivid colors on which play the ornamental motives of a color in a tone different from the ground, and here also they must desire that the eyes of the spectator should lose nothing of the design. That very natural wish led to simplifying the folds, which would not have failed to interrupt the development and effect of the decoration. Now to make prominent the forms of the body, to follow them and to clearly accent the principal lines, there are really only fabrics of a single color. That is because it will use only those fabrics, that the Greek costume in the best centuries of the art, will be especially that of the sculpture. Such as we represent it for the heros of Homer, it already has something of merit; but it does not yet have the elements that compose the entire part suiting them, and its fault is in its varied coloring on the one hand, and on the other in the reduction at the waist, that results from the mode of using the belt.

What is true of the peplos is likewise so of the feminine mantle. Under di ferent names given to it by the epic language, this seems to have been nearly always placed on the head, so as to cover the shoulders and back. It had no amplitude, and especially not the freedom of charm of the himation in which are wrapped the terra cotta statues of the classical age, with such charming fancy.

The headdress is also rather heavy; its appearance is complicated and formal. The contemporaries of Homer among men of high birth admitted abundant hair, which fell on the nape and on both sides of the face in long locks, often held in spirals of gold

of gold or silver; on the con.rary, from the time when s statuary flourished, the sculptor well pleased himself by increasing short and thick locks closely pressed to the brow, temples and ears. It will be the same for the women. They will omit the bonnet. At most they will retain a light veil, that will cover only the back of the head; but most frequently for them will suffice a simple band to retain the hair, whose wavy mass will form a marvellous enclosure for the face.

In the structure of the high headdress that conceals the entire head, in the pleasure taken in vivid colors a and complex designs, in that seeking for a rigorous symmetry, that presides over the arrangement of the clothing and the hair, finally in the luxury of jewels that largely extend over the breasts of women, in all that gold mingled with the pendant locks of the men, there is a remnant, a still sensible trace of the Mycenaean taste and the oriental influence. At Mycenae was a passion for the precious metals, for jewels of all sorts, and from the Orient, Greece will always borrow the type of many-colored fabrics, when needed for certain uses, charged with embroideriesand very showy colors. Yet already a reaction is pronounced and other tendencies are manifested. If the heros of the Iliad are charmed by beautiful and richly decorated arms, one does not see that they have on the body any ornamen other than those spirals that enclose their hair, and one cannot affirm that all have recourse to that ornament. It even seems that they regard as unseemly for a warrior the custom of wearing jewels; we believe that is found the expression of this feeling in a verse of the Iliad, where the poet says of Amphimacos, a chief of the Carians, that "he went to battle with gold on himself, like a girl."[1]

Note 1.p.275. Iliad. II. 878.

Then they are already in the way, that must lead to the adoption of the simplest and noblest of all costumes, the Greek costume, such as we admire in the most perfect monuments of statuary. The principle is established; but many years are required to produce its effects. In the marbles and on the vases of the 7 th and 6 th centuries, the

headdress and drapery retain much of that complexity, vain sumptuosity and stiffness, that seems to us to characterize Homeric clothing; still from one generation to another, they are modified slowly but surely, in the sense that we have indicated.

We should have liked to comment on and to illustrate Homer, to invoke the figured monuments more frequently; but we could scarcely do so without referring to works, that are at least one or two centuries later than the epic period, and fashion could have changed in the interval. Thus there is a risk to run in the use of the later documents. One can only use them very discreetly. The only monuments that date in an epoch very near the time when the two poems were completed in Ionia, are the vases in the geometrical style; b but unfortunately the images thereon are too summary to satisfy our curiosity on the subject of costume; the painter has given the appearance of nudity to nearly all his personages of both sexes. Yet the clothing is sometimes indicated (Fig. 59). Now there on the rugs stretched on the funerary beds, there is not that diversity, that richness of decoration, that according to the descriptions of the poet, seem to have been presented by the fabrics that he had under his eyes. All that one finds in the clothing of women and in t the tapestries of couches (Fig. 6) is the chessboard design. It is further possible, that men did not then possess at A Athens the beautiful fabrics made by Ionia, with the help of models furnished by Phrygia, Lydia and Phoenicia. In the 9 th and 8 th centuries, Asian Greece was much more industrious and wealthy than European Greece. Its princes were masters of a fertile soil, enriched by overland and maritime commerce, and displayed a luxury not rivaled by the Eupatrides at Athens, who did not have the same resources. Attica had never been fertile, and there was yet only a marsh, where the port of Piraeus will later be opened to thousands of ships.

Chapter V. General Characteristics of Art during the Epic Period.

From Egean, Achaian or Mycenaean Greece, as one prefers to call it, to the Greece that was slowly constituted after the invasion of the northern tribes, there is a sensible retrogression, a momentary diminution of labor and wealth, as of art and industry. That prehistoric Greece that has been reconquered from oblivion, thanks to the discoveries of Schliemann and his emulators, had industrial centres, where under the protection of opulent chiefs and friends of luxury, there labored groups of artisans among whom the secrets of the trade were transmitted from generation to generation. The works that left those workshops were distributed not alone in all oriental Greece among congenerate tribes; they were carried by way of the sea even into distant countries.

The workshops of Mycenaean ceramists had in Egypt one of their principal markets; by the faith of the paintings of certain Egyptian tombs, it even seems that also sometimes the works of the goldsmiths of Mycenae took the same course. If there were a history of those societies or merely a poetry that reflected their image, Cnossus, Orchomenes and Mycenae would find themselves mentioned in the same chapter, as in the later history of Greece are Ephesus, Miletus, Chalcis, Corinth and Athens.

In the Greece of the 10 th, 9 th and 8 th centuries was nothing similar, to judge of it by the Homeric poems, the only documents that give any idea of the life of the men of that time. If there were countries then famous for the exceptional qualities of the products derived from them, those countries were all situated outside European Greece. By numerous traits one divines that the Greeks of that time experienced no embarrassment in recognizing the superiority of foreign industry. The swords forged by the Thracians are all the more appreciated.[1] Under the fingers of the Lydians, ivory loses its whiteness; it is tinted with purple.[2] Objects of price are brought from Egypt and increase the luxury of Menelaus.[3] The cuirass of Agamemnon, a marvel of art, is a gift from Kinyras, king of Cyprus.[4] It is particularly P Phoenicia, for the contemporaries of the poet, that is the

mother of beautiful works of every sort. Among the different cities, each of which must furnish its share of exports, Sidon was so eminent, that at a distance all the cities of P Phoenicia were confounded with it in the eyes of the Greeks. Sidon is a city rich in bronze,[5] and that where are most s skilfully wrought the precious metals, according to the evidence of the two crateras of silver that Phedimos, king of the Sidonians, presented to Menelaus, and the necklace of amber and gold that served them to amuse and deceive the women of the house of the prince at Syros.[6] What one no less admires are the products of the women of Sidon, unequaled embroiderers. The peplos that Hecuba offers to Athena as a gift worthy of a goddess, was ornamented by the women of S Sidon.[7] Men envied him, who like Clesios, father of Eumea, possesses a Sidonian female slave, who "knows how to make beautiful works."[8] If those objects, contended for by all that could pay the price, were distributed in all parts of the Grecian world, the Syrian manufacturer did not await at home the coming of purchasers; he went to them; he had the gift of ubiquity. In the course of his tales, Homer mentions the presence of Phoenicians in many places, in Egypt,[1] where they remained permanently, in Crete,[2] at Lemnos,[3] at Ithaca[4] and in the mythical island of Syros.[5]

Note 1.p.278. Iliad. XXIII. 560, 561; 807-808. It has been asked (Helbig, L'epopee homerique, p. 12), whether those T Thracian swords did not come from Phoenician works established at the foot of Mt. Pangea. What has induced us to reject that conjectureis, that Thracian civilization appears to have had its own originality.(The same, Chap.I). I should rather believe in a centre of metallurgical industry analogous to that mentioned to us among the Chalybes of Asia Minor. By the routes from the North came to that region the processes and practices of that industry.

Note 2.p.278. Iliad. IV, 141.

Note 3.p.278. Odyssey. IV, 125-132.

Note 4.p.278. Iliad. XI, 19-28.

Note 5.p.278. Odyssey. XV, 425.

Note 6.p.278. Iliad. IV, 615-619. See Iliad, XXIII, 745; Odyssey, XV, 415.

Note 7.p.278. Iliad. VI, 289.

Note 8.p.278. Odyssey. XI, 418.

Note 1.p.279. Odyssey. XIV, 288.

Note 2.p.279. Odyssey. XIII, 273.

Note 3.p.279. Iliad. XII, 745.

Note 4.p.279. Iliad. XV, 482.

Note 5.p.279. Iliad. XV, 415.

While the poet thus attaches the ticket to a certain foreign workshop on each of the wrought pendants mentioned for their high value, he does not take the same care with regard to the objects not of exotic origin. When it concerns arms, tools, jewels or fabrics, he does not indicate the source, which seems to indicate that the quality is everywhere nearly equal. A single time in regard to the shield of Achilles, he names the workman Tyches of Hyle;[6] yet we do not even k know if it be necessary to recognize as the native place of Tyches the little Beotian city, that later bore that name.

Note 6.p.279. Iliad. VII, 221.

At that epoch in Greece were executed in the house by the members of the family certain labors; such as spinning of flax and wool, weaving and the making of garments. A single time is mentioned in the epic poems a poor woman, that occupied herself in the preparation of wool outside the house.[7] There is a beginning of independent industry, but a very w weak commencement.

Note 7.p.279. Iliad. XIII, 433-435.

As for other labors, those in the province of men, there were henceforth men of the trades, masons, carpenters and joiners, curriers, wheelwrights, blacksmiths and goldsmiths; but the tecnics for each of these professions must remain very simple. The division of labor was not carried very far. Each artisan had a very extensive specialty. The armorer also fabricated jewels.[8] Shields of leather covered with sheet metal were also made by the currier as well as the blacksmith.[9] The wheelwright and the carpenter cut in the forest t the wood that they used;[10] they only employed green wood, that could only produce very rude work. In those conditions the procedures could not be very scientific; thus every intelligent and energetic man practised the same trades if n necessary, that we are accustomed to regard as requiring a long apprenticeship. Paris built his house at Troy by working

with the best artisans.[1] Ulysses constructed with his own h hands his stone chamber, where he fashioned the nuptial couch that he made from the trunk of an olive tree.[2] In the island of Calypso, he is no more embarrassed in fastening together the planks of the raft on which he will escape from his prison.[3] Under the pressure of necessity, everyone is still the man to do everything. Eumeus himself built of rough stones the walls of his farm house; the sandals with which his feet are shod were cut from the fresh skin of one of his goats.[4]

Note 8.p.279. Iliad. XVIII, 401, 478-613.

Note 9.p.279. Iliad. VIII, 219-223; XII, 294-297.

Note 10.p.279. Iliad. IV, 485-486; XIII, 389-391; XV, 482-48

Note 1.p.280. Iliad. VI, 213.

Note 2.p.280. Odyssey. XXIII, 190-201.

Note 3.p.280. Odyssey. V, 243-261.

Note 4.p.280. Odyssey, XIV, 7-14, 23-24.

Nothing prevents domestic industry from producing fabrics of excellent quality, where the design and the mixture of colors would have a happy effect; but under such an arrangement the other industries, those treating stone, wood or metal, could not be carried very far. The workman only labored to satisfy the current need; so that he seems to have created nothing, that by its character of elegance of richness would merit becoming an article of export. According to some mentions in the epic poems and a commerce by barter to which the Greeks were parties, they supplied to the peoples from which then received objects of value, only raw materials like copper and iron, timber for building and hides, perhaps also animals on foot.[5] To the Phoenicians, those dealers in men, they also sold slaves, prisoners of war placed in their hands.[6]

Note 5.p.280. Odyssey, I, 184; Iliad, 473-475.

Note 6.p.280. There is frequent mention of these sales of slaves in the Odyssey.(XIV, 452; XV, 427-430; XX, 383).

Whatever the extent, arrangement and decoration of buildings, the luxury of the Homeric age seems to have been very inferior to that of the Mycenaean age. For arms, clothing and ornament, the difference is as sensible. Nowhere does the poet speak of swords with blades of the kind of those, that we so much admired on the blades of the celebrated d

daggers of Mycenae.[7] Nor is there any mention by him of anything resembling that sword hilt in form of a dragon, found at Mycenae, where the scales and the eyes are made of bits of crystal, carved and inlaid in a gold ground.[1] Had Homer under his eyes any objects of this sort, he would not have failed to describe them. Two exceptions are alleged, the c cuirass of Agamemnon and the shield of Achilles; but as for that cuirass, we are expressly notified that it is a product of Cypriote industry, i.e., of Phoenician work, and as for the shield, if the first idea might be suggested by some work of the blacksmith or goldsmith, the imagination has e extended freely on that theme; it has given to the decoration a complication, that could not have suited the reality. The poet himself indicates in presenting this object as the work of a god, Hephaestos. It does not seem that the bronze arms of the heros of Homer were generally very ornate, and the iron swords found in the tombs of the Dipylon appear to have been very simple. At most the hilt was perhaps ornamented by bands of gold or of ivory, with designs traced by t the point, which have been found in several of those tombs.

Note 7.p.280. Histoire de l'Art. Vol. VI. pls. 17,18,19.

Note 1.p.281. Schliemann. Mycenes, p. 369; Figs. 451-452.

The epic poems do not represent the kings and chiefs of the people as covered by those ornaments of gold, that were sewn on the garments of men and women in the course of the Mycenaean age. Some have thought to find a memory of that fashion in two verses, that show Zeus and Poseidon "clothing themselves with gold on skin;"[2] but the poet attributes that appearance to gods alone, and also it is perhaps to see there only a mode of speech, a vague image or touch of color, in which it would be an error to seek the indication of a certain detail of apparel. The egis is the sole object that recalls these rich plates of gold found on the breasts of corpses in the excavations of the Mycenaean acropolis; but poetry attributes the egis only to the gods Zeus and Athena. For men, even those above the others by their birth or rank, besides war equipment, it is the use of beautiful cloth, f fine and soft, that the shuttel or needle has decorated by a border of color and sober designs, similar to those traced by the brush of the caramist on the shoulder and neck of vases

In this respect the Greeks of Homer are nearer than the Mycenaeans to the Greeks of the classical age; as those do, they find themselves incited by the simplicity of their clothing, not to demand an effect as formerly from the accumulation and the gleam of metal overlays, but from the happy arrangement of the drapery and folds, that it forms on the body. Yet if such be the final result of the change introduced in the customs, one of the causes that have caused this change was perhaps even the diminution of the quantities of gold and silver in circulation. They had less of the precious metals to shape into buttons and pendants, spangles and jewels of all sorts, they found means to do without them, yet not for that renouncing the satisfaction of a certain innate taste for elegance and nobleness. Necessity has been the mother of industry.

Note 2.p.281. Iliad. VIII, 43; XIII, 26.

What the excavations reveal to us on this subject accords with the inductions, that we have derived from the statements od the poems. There are jewels in the tombs of the Ceramicos at Athens; but one can see now much in their weight and the originality of their decoration, those jewels are inferior to those taken from the Mycenaean tombs. Those appearing most advanced in manufacture, those bands of gold all covered by figures are interesting for the themes treated by the artist; but one feels that the workman economises the metal there. The thin stamped sheet, where the ornament is effaced by a slight pressure, has replaced the resistant and ductile plate, where the little chisel and hammer brought into relief images that have frequently retained all the freedom of their first relief. There are beautiful materials of which the Mycenaean artist made frequent use, and that his successor seems not to have had at command; for example, such are alabaster and rock crystal. No trace of them is f found in the tombs of the Dipylon, and they are not mentioned in Homer.

Certain types of jewels have disappeared, and thuse in w which Mycenaean art showed itself most inventive and most skilful; thus the rings whose bezels are ornamented by an image engraved in intaglio in the thickness of the metal or in a fine stone, that could serve as a seal. Homer does

not seem to know the use of the seal and rings are not named, neither among the pieces composing the ornaments made by Hephaestos, nor among the gifts by means of which the suitors seek to conciliate the favor of Penelope.[1] In the most ancient part of the Attic cemetery, aside from diadems, there are only those pretty jewels, that cannot be wanting where a woman was buried with her toilet equipment, hairpins, earrings and bracelets. As for the tombs where men repose, they most frequently contain only arms. Men were not accustomed to jewels, since they had ceased to conceal beneath the gleam of metal plates the texture and design of the fabric that clothed them.

Note 1.p.282. Iliad, XVIII, 401; Odyssey, XVIII, 292-301.

The precious metals had then become less abundant and rarer in use; in many cases, they had been replaced by bronze and iron, bone and clay; but men undertook to supplement the poverty of the material by the search for ornament. The historian would have no idea of what that ornamentation was, if he were reduced to seek his information only in the epic poems. Of what he sees everywhere and every day, the poet says not a word. His curiosity is aroused only before the works that are out of the ordinary, "i.e. before those of the armorer and the goldsmith, especially when they are of foreign origin; he mentions them alone to his auditors. Besides, the Grecian goldsmith did not advance the same as his other contemporary artists; with reference to them, sometimes he delays and sometimes he advances. He continues longer than them to be attached to certain motives of the repertory of the Mycenaean artist, and finally when he is freed from that tradition, he is the first to become inspired by the motives offered him by oriental models. Then it is not from the little that remains of his work, that it is necessary to ask why and how taste was modified in Greece, as a sequence of the shocks that led to the fall of the Achaian kingdoms. If we have verified this change, the difference has appeared to us particularly in objects where the material has no value; there are shown and everywhere alike, or at least inspired by the same spirit, the typical motives of the style, that we have called the rectangular geometrical style.

Taking this style where it adheres strictly to the resources drawn from its own possessions, when compared to the Mycenaean style, is it an advance or a decadence? The question is one of capital interest. According as one solves it in one or another sense, he will understand in a different manner the history of the Greek race and of its civilization, of the course that its genius has followed in the centuries, that may be termed its years of adolescence, between its obscure origins and the splendor of its full development.

For what is purely linear design, Mycenaean ornament with the method that it derives from the curved lineand its easy inflexions, furnishes motives more agreeable to the eye than is the stiffness of the straight line. The painter of the vases of the Dipylon vainly tried to complicate and vary his lines; even with the fret and its derivatives, those never attained the refined elegance and the suppleness, that his predecessor knew how to put into the scrolls of his spirals, where he also reserved a place for the rectangle, the lozenge and parallel lines. By contrast, these right lines being discreetly mingled with an entirety with a different principle, contributed to make the decoration more complex, and to vary its appearance.

Where the advantage of the Mycenaean designer is still more marked is in the part he takes in the imitation ofthe living form. During a certain time, that is represented on the bronzes and on the vases later than the Dorian invasion only by a single organic type, the marsh bird, to which are later added the horse and the man. As if the leaf and the flower had disappeared from the world, the plant is absent. On the contrary, in the artist of the earlier age one feels the passionate desire to profit by all the suggestions of life and of its inexhaustible fertility. Plants, animals and all amuse and inspire him. From the plant he demands not only the flowers, that like the iris, rose and lily, strike and charm him by the fragrance of their perfume, the elegance of their pose and the splendor of their color; he seeks also beneath the transparent water the long ribbons of the alges, where they undulate with the movements of the waves. Whether he takes his models from the flora of the sea or

that of the land, he groups in the happiest way

the elements of which he takes possession; he invents the scroll, i.e., the flexible branch that unrolls without end, ornamented by its flowers and its leaves. That arrangement, which gives a continuous ornament of such a pleasing effect, oriental art had not known.[1] Primitive Greece invented it, and this is in the heritage that classical Greece will seize on, after this motive had almost fallen into desuetude in the intermediate age; perhaps something of it was preserved in the goldsmith's works, that are now lost.

Note 1.p.284. A. Riegel. Stilfragen. p. 127.

It is the same when from the animal the painter and sculptor seek themes for ornamenting their works. There again t they are not satisfied with reproducing those types, that by their dimensions or the part that they play, seem to occupy a superior rank in nature. The great quadrupeds interest the artist, both the domestic animals and the wild beasts of the forests; he likewise makes use of the bird, that he represents as walking, flying or swimming; but wha has particularly aroused his curiosity is an entire order of forms, to which many schools of are have accorded very little attention; besides the insect with large wings and slender antennae, like the dragon-fly and the butterfly, there are the fauna of the sea, the fishes and mollusks.

One knows what special pleasure he took in placing on his jewels and his vases the image of the octopus, cuttle-fish and nautilus; the lines that represent the membranes and a arms of those mollusks have the same roundness and undulations as those that characterize the elements of his line drawing. He commenced by copying these types in the spirit of realistic accuracy; he ended by finding there a pretext for motives, that only distantly recall the forms of the model. Thus is explained what has been termed the Japanism of Mycenaean art; there is an entire vein of fancy, which always seemed exhausted when the geometrical style prevailed; yet it will later have in classical art abrupt flashes, but without ever flowing anew with as much abundance and frank peculiarity.

When from the choice and the nature of types, one passes to the study of the interpretation that has been given in relief, the comparison leads to an analogous result. The

Mycenaean artist is still very inexperienced. When he attacks the human figure, he finds in the complexity of its contour and in the variety of its attitudes, difficulties over which he triumphs very imperfectly. Even when he renders t there the entirety of the pose sometimes with a vivid accuracy; but it is particularly in the representation of the animal that he shows all his power; he carries into it a rare feeling for the peculiarities of the form and characteristics that distinguish the species. He has the task a and the gift of movement; he endeavors to seize on the stag, lion and bull, the play of the muscles stressed for running or leaping. In spite of the faults in drawing that nearly always escape him, when the image is not huddled in a narrow space as on engraved stones, one divines in his work the intelligent and sincere joy afforded to him by the spectacle of the display of force. With the engraver of brooches and the painter of the Dipylon is nothing similar; even when t they are emboldened to insert figures in their rectangular panels, their hands retain the habits contracted in the school of general design. In their paintings the figures remain angular and dry, fixed in a small number of poses, always the same. The animal is no more studied from nature than the man; it is no less conventional and schematic. The images are rather signs of ideas than copies of the reality, they recall certain personages and certain actions, rather than pretend to represent them.

We have arrived at the end of the comparison; it seems that the question may be solved. Mycenaean art is very superior to that which succeded it. Its domain is much more a ample; it has higher ambitions, that it succeeds in realizing in large measure. By the spirit that animates it and by the aptitudes that it reveals, by its manner of comprehending the form of life, by its qualities of warmth and spirit, the art of these tribes to whom we only dare to assign a n name by conjecture is certainly nearer the grand art of Greece than the art of the 10 th and 9 th centuries; across t that long series of years, it in a manner gives the hand to the classical art over the heads of the chiselers and painters of the school of the geometrical style.

Yet the artist of the latter school allows to be perceived,

even in the works that surprise and shock our taste, at least the germ od superior or iriginal qualities, analogous to those proved by his contemporary poets, the creator of epic poetry; in spite of appearances, he has not lost his time.

By the force of things, the advance was continued; society had improved its tools. Certain inventions were produced, whose benefits were gradually extended. Thus during these two or three centuries, the use of iron was diffused among the coast tribes of the Egean sea, and the employment of the new metal allowed the perfecting of the equipment of o offensive and defensive arms. Material had not alone to develop itself.

About the beginning of the same period, the arts of design appeared to have fallen very low, with this cold decoration from which is absent all image of life. Wen they commence to desire to arise, when they attempt to reproduce the figures of the animal and of man, they seem at first entirely unable to succeed in that enterprise. Almost an impression of barbarism is given at first sight by the paintings of the vases of the Dipylon, those personages with heads, bodies and members are represented by triangles, lozenges and sticks. One would say that the eye of the painter did not perceive, and that his fingers refused to trace the curves that define the contour of the form of the living being.

However, in the works themselves, we have discovered a character that we have not found in the same degree in those of the preceding age, the art of composition, a thoughtful composition, in which there already almost is science. we have indicated this same tendency in a work of a different kind, in the shield of Achilles, where the poet has arranged his themes and his groups as a contemporary goldsmith would have done, who had the same programme. In the creation of the potter as in that of the poet, one already feels announced one of the master qualities of the Grecian mind, its love of order and clarity. The genius of the race has then derived benefit from the intrusion of new ethnic elements, that have come to incorporate themselves with the Dorians. If by the violence with which they are omposed, those elements have cast confusion into the national life or even seemed

to suspend for a time the use of certain faculties, they no less contributed to form the substance of the complex genius of the great nation. With the alloy boiling in the crucible, they mixed atoms of a more solid and resistant metal; they had in the domain of art effects, that history has shown in another field, that the poetry of thought, of social and political organizations.

Likewise in this design of such a hard dryness, we have believed ourselves able to find a slight indication of the sense in which the art of adult Greece will orientate itself, when it shall dispose of all its resources. In the nudity of those stiff and thin figures, where the muscles alone of the arms and especially of the legs are marked with a desired exaggeration, one divines as already apparent although very involved and powerless to explain itself, the idea that will be formed of its beauty, when there commences later to form itself, a race that labors passionately to develop in itself strength and agility by the assiduous practice of gymnastic exercises. Observe on the vase of the Dipylon a certain dancer that leaps, a certain runner with body extended and leaning forward; this is the caricature of "Achilles with light feet," such as the poet represented him, or if one prefers to take a comparison in classical sculpture, of the Apollo Belvedere;--

"Intrepid runner with the slender waist,
Who follows his sister Diana through the forests."[1]

Note 1.p.288. Brizeux. Les deux sculpteurs.

Behind the awkward and grotesque image, one sees the type of which the artist has a very distinct conception from that moment, which he contemplates and models in thought, but which he yet does not know how to realize in concrete form.

We desired to succeed in defining with sufficient precision the character of the period, that terminated about the year 750; but the task was difficult. To form for ourselves some idea of the course pursued by the arts of design, we must have utilized both the information borrowed from the poems that received their final form in Asian Greece, and that furnished by the monuments that nearly all come from European Greece, or as better said, from Attica. It only remains to complete that analysis, to call attention to

considerable part then taken by Athens in the elaboration of the elements of the geometrical style, and in the movement that led to replacing it by another style, richer in promise and to which belongs the future.

We have believed ourselves able to recognize in the geometrical style a contribution of the tribes termed Dorian, and if this style is good, as we have sought to establish, the development of a system of ornamentation with its roots in the primitive civilization of central Europe, we should expect ourselves to prove that its evolution was accomplished by the agency of peoples, who possessed its hereditary and direct tradition, and that had diffused south of the Balkans in the basin of the Egean sea the characteristic methods and motives. Now affairs did not proceed thus.

At Athens this style made all the progress allowed by its principle, and that ended in applying to the representation of the living body the processes of drawing, that had been applied to the execution of purely linear decoration; however Attica, whose inhabitants claimed to be aborigines, had never been occupied by the Dorians. Is there not something strange, unexpected and paradoxical as it were, in that initiative thus taken by the industry of Athenian ceramists?

Here is what also adds to the surprise caused by this discovery; the Athens of distant centuries, before Solon and Pisistratus, is scarcely mentioned by history. Judging by the evidence of the authors, Athens only played a very faint part until the middle of the 6 th century. Far from being able to rival the great Ionian cities like Ephesus and Miletus, it had not in contenental Greece even the importance of Argos, Sparta, Corinth and Chalcis. Quite a different impression is left on the archaeologist by the examination of the monuments. There has been seen what place we have been compelled to give to Athens in this study of the most ancient Grecian art and of the industries connected therewith. In the 9 th and 8 th centuries at Athens, ceramics had the highest aspirations and was most inventive. There is at least the appearance of a contradiction between the statements of written traditions and those collected by the archaeologist. This disagreement cannot be neglected by the

historian; he is obliged to seek to explain it.

In their days of power and glory, the Athenians partially lost the ememory of their own past, as if dazxled by the splendor of the present. All retained by them were certain myths, like those of the exploits of Theseus and of his victory over the Amazons, which flattered their vanity; there are also some names of heros and of princes more or less legendary. This ardent and mobile democracy were not ignorant, that their fathers had lived under an entirely aristocratic rule for several centuries;[1] but it had only a vague idea of those institutions long since abolished, and especially it did not eender to itself an accurate account of t the degree of comfort and ease that numerous generations m must have owed to them. Perhaps mith the variety of the means of research at our disposal, we are today better able to divine without too many chances of error, what this prehistoric Athens might be, and what resources were at her disposal.

Note 1.p.289. Aristotle. (Greek).

During the two or three centuries that followed the Dorian invasion, Attica was governed by those Eupatrides, whose descendants, before the Median wars, must also take such a brilliant part in the creation of the grandeur of Athens. The state which then had Athens as capital did not aspire to the glory of conjuests; it did not associate itself with that movement of colonial expansion in which two neighboring cities distinguished themselves, Corinth and Chalcis; but sheltered behind the mountains that always served it as frontiers, it had already attained that political unity, reached by other groups of the Grecian world only much later or even never. Thus it was almost entirely preserved from those murderous contests, that elsewhere and for example in Beotia kept at war cities whose territories adjoined. Under the respected authority of families, that passed as deriving their origin from heros sung by Homer, it had prospered. T The goound was cultivated with more care, as it was more s sterile in many districts of Attica. What it refused to yiield in spite of this stubborn labor, was easily obtained from abroad, thanks to the ports, some of which faced Asia and others the Cyclades and the Peloponessus. Those ports

were watched and the entire coast was efficiently protected from the pirates by that institution of naucraries, a trace of which we believe is found in the paintings of funerary vases. By the favor of the security thus guaranteed, professional skill was developed among the **artisans**, who in the urban group, whose centre was the ancient castle of the Erechtheides, labored for the king and nobles. The ivory figurines and the stamped diadems of gold have given us a good idea of the skill of the carver and of the goldsmith; but the subsoil of the plain of the Cephisus furnishing a clay of superior quality, it was especially the industry of the ceramist that took a rapid flight. What stimulated its activity was, that for the excess of its products it found assured markets in adjacent, and even in very distant countries. Before copying the vases of the Dipylon, the Beotians commenced to purchase them at the market of Athens; they are taken today from the cemeteries in the vicinity of Thebes. I These vases are easily recognizable, and specimens have even been collected in the cemeteries of the Sicilians, among w whom commerce carried them before any Greek colony had been founded on the coasts of Sicily.[1] Henceforth a notable profit was derived by Athens from that exportation.

Note 1.p.290. In the Sicilian cemetery of Finochito, Paolo Ossi found pottery of the geometrical style, in whose decoration enters the fret, which is the favorite motive of the potters of the Dipylon and their mark of fabrication (Bull. di. Paleon. ital. 1894, p. 23-37; 1895, p. 182-183). He showed them to me at the museum of Syracuse, and according to all probability, those vases came from Athens.

Matters being thus, when the geometrical style came to be substatuted in Gre ce for the Mycenaean style, that had exhausted its vein, where could this new style find to flourish and expand, conditions more favorable than in Attica, which had escaped the evils of invasion, and where the potter by a well regulated rule and sheltered from internal t troubles, had at his disposal the fenest clay ever employed by the ceramist? Doubtless it was by the intermediary of t the tribes from the North, that occurred the renewal of the repertory of the ornamentist, and it seems proved that those tribes in their march South did not pass over Citheron and

Parnassus, that they only supplied elements of some importance to the people of Attica, where Ionian blood has always dominated; but it also appears that from the time when the Dorians still dwelt around Parnassus, Athens had already e entered into certain relations with them, and in what is related of the expeditions of the Heraclides conducted against the barrier of the isthmus, there is a certain trait that evidences these same amicable relations. Further, the Dorian states were established in the vicinity of Athens in Argolis, at Corinth and in Megaris; also there was a contanual movement of exchanges between Athens and the islands as at Thera, where were opened workshops that produced beautiful specimens of the style in fashion. In one way and another, the potter in Athens then had been soon initiated into the practice of methods of decoration, which then tended to peevail. By a happy combination of circumstances, he found himself better placed than any other to derive from the system of forms adopted, all that this could give him, and to introduce therein themes, which by their nature did not seem intended to enter into his works; thus he will preside over a last and decisive change of the style of painting on vases, by the effect of this incessant labor and under the influence of oriental types. In the study that we made of his work, we stopped at the moment when his hand b began to model and his brush to decorate the vases called proto-Attic. Now while those still betray much inexperience, they already by the character of the subjects chosen by the painter and by the charm assumed by his design, announce the works that will be produced by the masters of the 6 th and 5 th centuries.

Thus in that Greece in formation, that for want of a term defining it more accurately, we have termed the Greece of the epic period, that Athens which seems to live such an obscure and isolated life, is already in certain respects in advance of even the cities, which by the powers displayed as explorers of unknown seas and as colonizers of barbarous lands, appear to march at the head of the Hellenic races and to personify the genius with the greatest splendor. Athens is doubtless still far from the time, when she will erect on her Acropolis temples of white marble, and where on the

pediments of those edifices, one will place statues that we admire, however mutilated they may be, as the most perfect works of Grecian sculpture; but those elevated forms of art are nowhere represented in the course of this period, no m more than the enterprising and rich Ionia, than in insular Greece or on the European continent. There was then in Greece scarcely any other art than industrial art, and in at least one branch of that art, Athens has a marked superiority over all other Grecian cities; none of them possessed workshops in which were fabricated pieces, that by their dimensions, by the nobility of their decoration, and by the interest of the themes represented on the clay, were comparable to the great funerary vases that surmounted the tombs of the Codrides and the Melanthides. We are accustomed to venerate and cherish Athens as the incomparable educator of mind and taste, to seek our models in the writings of her poets, historians, philosophers and orators, architects, sculptors and ceracim decorators, behind which we divine P Polygnotus and Zeuxis. Under the control of those sentiments, it is not without pleasure mingled with some surprise, that we have labored to bring to light the precocious merits of the potters of the Dipylon; we have been happy to render j justice to their patient and sincere efforts, to see them with all their awkwardness, already in advance of their contemporaries in other Greek cities, and by the beautiful arrangement of their decoration as well as by the generous ambition revealed, to laboriously prelude the future masterpieces.

BOOK III. ARCHAIC GREECE.

Chapter I. History and Religion.

After the first olympiads, Greece finally commenced to n have a history, that still comprises many gaps, but whose web already presents some consistency. The threads of this web have been woven by Greek authors, Herodotus, Thucydides, and many other writers whose works are now lost, but whose recitals were at the disposal of the annalists and compilers of the last age of antiquity. Even the most ancient of these historians, it is true, were only for the period preceding the Median wars, contemporaneous with the facts then relate; but the use of writing was diffused in Greece from the 8 th century, when those inquirers began their examination, they could consult authentic texts engraved on wood, bronze or stone. For all not supplied to them by the inscriptions, w which then if not rare, were generally brief and concise, they had recourse to oral evidence; they collected traditions still living and fresh, preserved by the pride of families, corporations and cities. Those creators of history felt at first that this was distinguished from fable by only a single condition; it is necessary for it to be based on a systematically established chronology. This chronology, they sought its elements in the calculation of generations, and particularly in official documents, such as lists of v victors at the great games, of priests and priestesses, of eponymous magistrates. These were not able to make it complete or certain in all points; yet they constructed the framework with sufficient stability, that the minds of their readers seized the order in which succeeded the events that they related. Modern science has gathered, compared and criticized all those statements; it has checked them by the evidence of epigraphic monuments that have escaped destruction; it has grouped them so as to form a series of facts whose sequence merits all confidence, although many details escape our grasp. The direction and progress of the social and political development may be followed without difficulty The fundamental dates are fixed. The grand lines of the masses are clearly distinguished; the figures of the principal actors, men or peoples, are drawn beneath the light, that without always being as bright as we should wish, still al-

allows one to define the particular physiognomy.

What has contributed to facilitate this retrospective co-ordination is, that from the Dorian invasion and the transmarine migrations for which it gave the signal, the Grecian world has found a location and is solidified. Doubtless the equilibrium there established comprises many oscillations. The cities composing it are passionately attached to their independence, to their autonomy, as the Greeks said; none of them renounced it voluntarily. Those most ambitious and most powerful succeeded in imposing for a time their supremacy or hegemony (this was the standard expression) on a certain number of the weaker cities; but those groupings only have a mediocre stability. Menaced by the jealousy of those that they alarmed, they contained within themselves internal causes of dissolution, and thus one sees rapidly weakened and degraded a certain State, which had played a very brilliant part, while another was previously obscure and then aspired to the first rank; bloody conflicts occurred, that changed the respective situations. Yet one and another people, that which lost its external dependencies as well as that which begins to make its ascendency felt afar, maintained themselves and continued in the territory in which they had built the temples of their gods, and where from generation to generation they had deposited the remains of their dead. Victims of secular hatred, some cities disappear, like Pisa destroyed by the Eleans and Orchomenos by the Thebans; but a people does not perish. Reduced by the Spartans to the condition of serfs or driven away as a prey to the miseries of exile, the Messenians will revive one day and will repay their former conquerors for the violence committed.

Thus connected to a definite portion of the soil on which they graved their names and made their ineffaceable imprint, the Greek tribes are not condemned to immobility. Each of them thenceforth has its point of attachment, its prytaneum where the sacred fire burned on the altar of Hestia, the goddess that presides over the indissoluble union of men a and the earth; but all or nearly all have held it in honor not to shut themselves within their narrow domain, but to take a more or less active part in the occupation and peop-

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peopling of the coastal countries of the Mediterranean. The Hellenes never moved so much as during the three centuries preceding the Median wars; never have their ports equipped and delivered to the wind so many ships, manned by bold companions not frightened by the perils of the seas and of unknown lands, bitter and murderous conflicts, relations to be established in barbarous countries by tact or firce, unforeseen accidents, combats in which the bands seeking fortune threw themselves on an enemy nearly always in superior numbers. This is the moment of the great colonial extension. Certain cities of the first importance like Miletus, Chalcis and Corinth, then scatter by dozens the growing cities along the coasts of the Black, Egean and Adriatic seas. Others like Megara and Thera, that are only of the second or third order, found colonies that soon surpass them in wealth and power. Then from the pillars of Hercules to the foot of the Caucasus, and particularly in the basin extending from the coasts of Ionia to those of Sicily, there is a rapid s succession of adventurous points extended in every direction, the prodigious energy of a force that does not reckon with obstacles and danger, of an inquiring soul projecting itself into space, on every side that a way seems to open before it; this is the effervescence of an abounding and o overflowing life.

In spite of the extreme diversity of these enterprises and episodes that distinguish one from another, the impression left by the study of this epoch is not that of disorder and of confusion. The historian no longer experiences here the same embarrassment as before the unexplained moments of the preceding age, before those sorts of pools and eddies of the human surge, that precipitated on Achaian Greece the northern tribes, and caused to flow into the islands of Asia Minor the ancient inhabitants of Hellas. To orientate one's self among all these expeditions and foundations, there is a guiding thread. It is known from whence comes e each troop of colonists; each colony has its metropolis. On the other hand, the colonies from the same metropolis are generally nearly all adjacent in the same region. The eye then follows on the map all the routes by which those emigrants have passed, and the mind has to make an effort to

effort to connect those different groups at their starting and stopping points. Each one of them appears to it as the prolongation of one of the main branches of the Hellenic trunk, like the posterity of one of the principal cities of European or Asian Greece, as the extension of one of those States, small by the area of their territory, but great by the energy displayed by the ambition, where the Greek genius has become conscious of itself and has commenced to prepare itself for its high destinies.

This genius first manifested itself in words alone, by w words subject to the laws of rhythm, by poetry. While this produced works like the Iliad and Odyssey, sculpture still sketched art under images, of the sort of those statuettes of ivory furnished to us by the tombs of the Dipylon, of t the figures that decorate the painted vases supplied by the same cemetery. When from one attempt to another, art came to use more freely and with more success the means appropriate to it, this was the time when made itself felt the living impulse of that centrifugal force, that cast in all directions to distant and still unknown shores, the seeds of Hellenism and its fruitful germs. One cannot imagine circumstances more favorable to the progress of art, that would promise it a finer flight. From year to year the young nation saw its domain enlarged and the organic centres multiplied. Now the more numerous are those among a people, the more chances for unity not to stifle variety. That is a law of history, a law verified as well for ancient Greece as f for Italy of the 15 th and 16 th centuries of our era. All children of the Greek race have the same blood, and in a certain measure the same natural aptitudes, the same traditions and the same religion, an entire ground of education and of common habits; but many among them, those detached by emigration from the mother country, were planted in very diverse surroundings, where they were subjected to the influence of very dissimilar climates and contacts. So dispersed, they could not remain as similar to each other as they were at the time the separation occurred. That eventually with the distances that perpetuated its effects must necessarily modify the character of the defferent groups; it was inevitable that here should be developed some quality less

brilliant elsewhere, while there would be emphasized some tendency scarcely indicated in another part of that vast entirety. The tree would be the same everywhere; but its flowers would not everywhere have the same colors and its fruits the same savor.

For example, take the Greeks that live on the coasts of Asia Minor, and at the mouths of its great rivers, who matain daily relations with the Lydians and the Phrygians, by the intermediary of which they are in communication with t the empires in the oasin of the Euphrates. Also the others established in Egypt among the grand monuments of the oldest civilization of the ancient world, and finally others settled in the islands and at the bottom of the gulfs of t the West, among the tribes of the Sicules, Italiots and Celts. Now Asian Greece created the elegant and rich forms of that Ionic order, for which it borrowed the art elements of the peoples of Asia, and it has always retained for that t type a very marked preference. On the contrary, the Greek cities of Sicily and of Italy were daughters of the cities of continental Greece, where by the substitution of stone for wood, the architecture called Doric was born of the traditions and practices of Mycenaean construction, where the temple was only an enlarged and embellished ample hall of the Homeric palace. They when they set themselves to build the dwellings of the gods that had presided over their foundation, they could only be inspired by the examples given by their metropolises; the Doric style is long the only one that they knew how to use; but living an independent life beyond the seas, having at their disposal materials not those employed by the workmen of the native country, animated by that pride produced by rapid growth, they aspired to erect edifices that should be larger and more beautiful, than all built previously. Then even when they do not manifest that ambition, they i troduce curious variations into the style that they have received and adopted, which renew it and diversify it infinitely. Turning our eyes to another side, if we go to study at the mouths of Nile at Naucratis, which was the most important of the trading cities established by the Greeks on the shores of the delta, a different phenomenon attracts our attention. The architecture there

is even that of Ionia, from which originally came most of the inhabitants of Naucratis; but among the objects taken from the trenches one gathers in great quantity glazed terra cottas, similar to those produced in all antiquity by Egypt and Phoenicia. After being initiated into the procedures applied in the workshops of the country, the artisans of Naucratis made an effort with no great success to diffuse in the Grecian world a taste for those enamels, whose tones of red and yellow, green and blue, charm the eyes of orientals and of the barbarians, that they had as patrons.

We could multiply these examples; by taking successively the most distant colonies and the groups that they compose, it would be easy to show that each of them has its originality, which is explained by local causes. It even seems at first sight, that the effect of these causes must have been exerted on certain of these groups even more strongly, than was the case; what is surprising is, that the extreme distance and the apparent isolation, and that the difference of location may not have had more sensible effects. The Greeks that occupy these posts of the advanced guard have remained Greeks, under whatever sky that the spirit of adventure has thrown them, whatever neighbors were given them by fate. Nowhere, at least during the first centories following the establishment of the colonies, have they permitted themselves to be injured by the peoples of different race and of interior civilization, that surrounded them and sometimes crowded them; nowhere have they forgotten their language, their poets. Never have they ceased to feel themselves members of the same body. These autonomous States were far from having the same social and potitical government; the creative genius had not everywhere the same sap and the same face; in all cases it did not follow the same paths everywhere; but all those cities, each in its way and according to its resources, interested itself in the common work of Hellenism; with steps more or less assured, they followed the movement and labored to associate themselves therewith. One knows w what a predominant part was taken in the first stages of G Grecian thought by the sages of Ionia and Sicily. In another order of ideas will be seen on almost every page of this book, with what ardor and inventive boldness the architects,

painters and sculptors, in those countries have contributed to the arts of design.

What preserves and perpetuates the unity of the nation, in spite of the action of the forces that tend to destroy it, is the continuity of the relations maintained between them, despite the extent of the spaces interposed, those s scattered brothers, all those that claim the name of Hellenes; they are too proud of this to allow their right to be proscribed. Doubtless the Grecian colonies are all in relations with the foreigners, here with those ancient kingdoms of Asia and Africa, where they find much to learn, there with barbarous tribes civilized by their contact, nearly e everywhere with Semetic merchants, which they find on every sea and in all the markets frequented by them. Yet always among themselves and with their metropolises did the Greek cities have the most active commerce. Those raw materials which they received from the aborigines, they sent to the artisans of the mother country, who were to transform them. From the workshops of Miletus and Ephesus, Chalcis, Corinth and Athens, they derived the most precious of the articles of luxury used by them, and which they likewise placed among their patrons outside, those fabrics, jewels, metal vases, arms sought by the barbarians, painted vases that the Campanians and Etruscans loved to enclose in their tombs. Corinth in the 7 th century, and Athens in the 6 th, exported by thousands the pottery fashioned by their skilful workmen, and by intermediary of the Greeks established in the vicinity of the patrons to be served, they distributed the products of their manufactories. Where to increase their gain those products were imitated, all at least borrowed their models from the capitals of industry and art.

Thus between Hellas and its most distant colonies was an endless series of going and coming, an uninterrupted exchange of merchandize. The ships that sailed on the Euxine, E Egean and Adriatic seas, with the cargoes that filled their holds, transported men with curious and discreet minds, always ready to repeat what they had heard, to relate what t they had seen, who by their conversation and tales nearly filled the place of the modern journalist; they carried rhapsodies that disseminated everywhere the knowledge and

love of the national epic poetry, of poets that aroused and nourished in souls the memeory of the myths, wherein each fraction of the Greek race was pleased to seek the secret of its origin, of its titles of honor.

The Greeks of the colonies further did not limit themselves to collect the benefits of the relations produced by commerce; even beyond all thought of money, their desire intervened to multiply the occasions for meeting. They had a firm intention to remain in communion of ideas and feelings with the inhabitants of the mother country; they wished to go as frequently as possible to renew themselves at the source itself from which had emerged the river, which divided into so many branches, and to take there a bath in Hellenism. What marvellously served them in that design was t an instution, that of the great gymnastic games, which were born from ancient customs witnessed by epic poetry and by the monuments of sculpture, and developed in the course of the 7 th and 6 th centuries, so as then to assume its definite form, and henceforth to hold a great place in the life of the Greek people. Those games returned at periodic intervals, some every five years and others every three years. The most august of all were the Olympic games celebrated in the valley of the Alpheus. One knows what precautions were taken that nothing, not even the internal wars that desolated Greece, should disturb the solemnity. A sacred truce, that the edelgates of the Eleans notified to those interested at the same time announced to them the date of the approaching festival, assured free access to the sacred valley for all that proposed to compete or to be present at the a assemblage. The Pythian games had as theatre the plain of Crissa in the vicinity of Delphi at the foot of Parnassus. Men flocked there with almost as much enthusiasm as to Olympia; the victories won there were hardly less esteemed. The Nemean and Isthmian games never came to the same prestige. Yet by reason of the opportunity of the site between the two halves of continental Greece, and at the gates of the rich and voluptuos Corinth, likewise attracted very great multitudes. Finally, when Athens with Pisistratus and his sons commenced to play an important part in Greece, its grand Panathenaic games, which had remained until then an

entirely local festival, also took a panhellenic character.

How much sought were the triumphs obtained there is attested by the clay amphoras, to which archaeologists have given the name of panathenic vases. On them beside the image of Pallas is always the same inscription:- (Greek). Those amphoras were given as prizes to the victors in these games; they were given to them filled with oil that came from olive trees belonging to the goddess. Those vases have been found in tombs at points of the Greek world very distant from each other, as well in Cyrene, Sicily and Italy as in Greece proper, which permits one to divine that men came f from all parts to contest at Athens for the crowns, that t the city bestowed in the name of the daughter of Zeus, her celestial and immortal protectress.

For a long time there were only the inhabitants of the a adjacent districts to take part in these "panegyries", as the Greeks termed and still call them; then as new needs a awoke in the Greek people, as they had a clearer conception of the noble ideal, that its uriters and artists must have busied themselves to realize, the attraction of those festivals made itself felt in a radius of increasing extent. The eyes of the spectators there enjoyed the vigor and agility displayed before them, long made supple by the exercises of the palestra, and the muscles of the athletes; but t the intelligence also found its place there. Everywhere competitions in music and poetry were added to the contests in strength and fleetness, an foot races and chariot races. No mastery of the body or of the mind, no form of talent did not have opportunity to manifest itself, and in a race so sensitive to praise, so charmed with glory as the Greek race, it was an honor passionately desired, to hear one's self proclaimed victor in one of those games, with the applause of the multitude.

From generation to generation, there appeared more competitors for each competition, and coming farther. What also aroused their ambition was, that in the official announcement of the results, the herald added to the name of the winner that of the city which had given birth to him. When one of its sons entered the lists, that was then personally interested in the result of the contest. What an enthusiastic

reception was also reserved for that one of its champions, who won in one od the great games and brought the crown of the leaves of smallage or of oak! An entire people rushed toward him, and sometimes to give that illustrious compatriot a more striking evidence of public recognition, they desired him not to enter by the ordinary gate; to allow him to pass a breach was made in the enclosing wall. Then were rejoicings without end, festivals at which resounded the odes in which the poets mingled with the eulogy of the man that of his country, whose origin and warlike prowess they recalled. At the same time to perpetuate the memory of that success, there was erected in the sacred forest surrounding the god a statue, deemed to reproduce the features of the victor, whose name was engraved on the bronze, with that of his natal city.

It is understood that the prospect of such high rewards would arouse ardent emulation. This was so from the 6 th c century. In all German cities of some impottance the kings, where exceptionally that dignity was retained, the tyrants, who needed pardon for their occupation, the nobles, heirs of the prestige and wealth of aristocratic cities, and finally all those seeking popularity, aspire to these crowns. Now those competitors or their representatives, the drivers of their chariots in the arena, do not go alone to the ground. A famous athlete is followed by a number of his fellow citizens, and there was a no less number when a prince sends his horses into the stadium. Friends and subjects wish to be there, to lend their champions the support of their encouragement, and then if he conquers his rivals, to take their part in his success. Thus the multitude found itself c composed of the most different elements, and for the few days of the duration of the festivals, it crowded around t the sanctuaries. In that crowd, where were spoken all the dialects of Greek, how many unexpected meetings occurred! They recognized guests not seen for many years and members of the same family, that the chances of emigration had divided into several branches. How many questions and replies must arise from those returns of the past, all those inquiries made to establish degrees of relationship, mutually to render account of all that had occurred everywhere, since

they were dispersed to the four winds of the heavens.

Further, that was not the sole pleasure of this sort that these assemblages had to offer, nor the sole form of the action which they exerted on the minds, to bring them to the same modes of feeling and thought. All present were continually called on by the conditions of the festival to give the same tone, if one may so speak, like as many instruments played in unison. They followed the same processions and were associated at the same sacrifices; they sung the praises of the same gods, whose wisdom and will were expressed for them by the same oracles. Finally, henceforth they had the privilege there of entering into relations with the interpreters of the highest conceptions, to which were elevated the genius of their race. Surrounded by a circle of auditors, whose curiosity never wearied, the rhapsodists recited Homeric poems and those cyclic poems that were their sequence; thus were engraved and preserved in the memory of all those long series of mythical personages and of varied adventures, in which from that time the artists in whatever city they labored, commenced to seek the themes that they developed. When the vein of epic invention failed, from lyric poetry and t the rich diversity of its metres the Grecian soul demanded the means of translating i.s ideas and of manifesting its emotions. Ideas and emotions express themselves in the poet only to be diffused, borne on the wings of the rhythm, to go to affect the minds and move the hearts. Elegiacs like Callinos, Tyrteus or Theognis must love to make heard in t those reunions the pieces in which breathed their patriotism or their anger, the inflamed exhortations addressed to their fellow citizens, the invectives uttered against their political enemies. As for the masters of what has been termed the choral lyrism, Ibycos and Stesichore, Simonides and Pindar, was it not in view of these same festivals, that t they composed their epinicies, those grand triumphal odes, whose execution required a stage, a collaboration of voices and instruments, for which they could count only on the satisfied vanity and interested munificence of the visitors of the arena? Thus poetry contributed in various ways to create in this intelligent and sensitive public a collective soul, that survived the dispersion, that obstinately resisted

the effects of all the dissolving influences, and which constituted the moral unity of the nation.

In order to reduce to a minimum the expenses and the fatigue of the journey imposed on the inhabitants of the colonies by attending those assemblages, it was necessary for them to be held in a country placed midway between eastern and western Greece, between the coasts of Africa and of Illyria, of Thrace and of Scythia. Thus toward the south of the Hellenic peninsula, between the long chain of Parnassus and the sea bathing the shores of the Peloponessus, arose the temples toward which were turned at fixed times the eyes and steps of so many thousand men; hardly a few days of walking or on boats separated these places of assemblage.

That so closely limited region was that wherein the Achaian heros had built their strong castles, where they had r reigned over those old cities, which had thrown even into the paintings of the epic period the reflection of their w wealth and power. It was also in this territory or on its frontiers that were founded the most ancient sanctuaries, to which were attached the myths, like those of Delphi and Athens, of Corinth and Olympia, that had most occupied the Greek imagination and gave birth to the noblest divinities that it adore, and to the most popular cults. Finally, it was there that the socalled Dorian invasion had come to superpose on the primitive inhabitants of the country a new layer of people, and that these elements as if shut and pressed in a closed vase, were mingled but without being confused, that they had exerted on each other reactions sufficiently strong and prolonged, that all should acquire common qualities, and thus create the race, altogether one and composite, which under the name of Hellenes has made such a great figure in the world.

The Peloponessus with the lands facing its northern coasts along the Saronic and Corinthian gulfs, thus at the beginning of historic times was the heart itself of Greece, and in a certain sense it always retained this character a and privilege. Yet not there occurred in the course of that period the most useful work and the most deciced progress, where the Greek genius produced the most original works, those that contributed most efficiently to prepare for that

full flight of letters and of arts, whose signal will be g given by the emotions of the struggle against the Persians and the unexpected victories that terminate it. Until the approach of the 5 th century, the Greeks of Asia are in ad-vance of those of Europe. Why and how was this so?

This phenomenon had multiple causes, some of which escape the historian. He is too far from that distant age; he knows nothing of the acquired tendencies that could bring into A Asia Minor a certain tribe, or of the merit of the chiefs that presidend over its establishment. What he sees is that the surroundings into which the Eolian and Ionian colonists had fallen were particularly favorable to the development of their native qualities. The field had more amplitude, t the lines were drawn at a greater scale than in Hellas. In Asia on whatever side one turned, there was before him more air and space, a more open sea, lands that extend and open more widely, where the plow cutting into the deep soil can take a course entirely different from that in the limited plains, narrow and stony ravines of Attica, Argolis and Achaia. The Hermos, Cayster and Meander are not like the Cephisus, Inachos and Crathis, torrents with water only in winter or after storms of rain: they are true rivers, that can carry boats in their lower courses, and whose discharge in any case is sufficiently abundant to suffice in every season to water the countries traversed. Those rivers had opened between the mountains bordering them passages suffi-ciently wide, that there was found place for roads followed by men and beasts of burden.

The roads that start from the coast and rise with the beds of the rivers lead to the interior and very fertile plains, and farther on to high plateaus easily passed over in all directions; they lead to the country inhabited by the Lydi-ans, Phrygians, and behind those the Cappadocians, peoples all in relations with the Assyrians and Chaldeans through the defiles of the Taurus. By those routes that nature her-self seems to have traced on the earth, merchandize of all kinds descended toward the coast of the Egean sea, where were founded the principal Eolian and Ionian cities. Those sold both the varied products of the soil and those of the culture of the flocks or of the chase of wild beasts; but

what were especially prominent in their markets were objects of luxury, metals and wrought ivory, jewels of skilful workmanship, woven and embroidered fabrics of many colors, created and exported from time immemorial by the industrial c centres of the basins of the Euphrates and the Tigris.

The cities in question rapidly became the marts of commerce, which by their mediation brought into relations western Europe and all western Asia. With the wares of all sorts t that came thus to fill the warehouses of the merchants of Smyrna, Ephesus and Miletus, exotic ideas, myths and symbols originally from Phrygia, Cappadocia and even from Chaldea, sketches of scientific theories, information collected from every complaisant source, flowed over foreign nations and the countries inhabited by them. By the same ways were also gradually transmitted, with the use of many relief types and many motives, the secret of certain technical prodedures and of certain tricks of the hand. Days that opened on the world and on its depths, when were seen both the confused swarming of savage tribes and the imposing outlines of great military empires, of their populous capitals, above which were sumptuous and richly decorated edifices. As if borne by the wind, words spoken beneath other skies and in unknown tongues came to the ears of the coastal inhabitants of the Mediterranean; These understood them; in traversing the space, they found in their course officious translators. There was in the movement of the caravans directing themselves to those ports, like currents of material and moral life, which issued from distant sources and converged toward some common reservoirs, there mingling their waves. These relelations, more suggestive as they remain incomplete, these echos of foreign voices not stifled by distance, these meetings and their surprises, these contributions of Asian workmen intended for the European consumer, were so many appeals to the curiosity, the instinct of discovery and the spirit of enterprise. Nothing was better calculated to spur and excite minds, to arouse in them the passionate desire to show themselves and to extend in all directions, in the realm of thought by literary and artistic creation, in that of the body by bold exploration, by the foundation of agencies profusely scattered everywhere, agencies that each ensured new markets for maritime

commerce, and supplied materials not previously put into c circulation.

In these conditions, several cities of Asian Greece had a growth whose rapidity was prodigious. At Ephesus the Greeks had found an ancient Lydian or Carian sanctuary, around which assembled the tribes of the vicinity. They appropriated its cult, after contests of which we know little save the result, and the reputation of their Artemis, the goddess w with a hundred breasts that represented the eternal fruitfulness of nature, was for much in the importance very quickly assumed by the city. Ships crowded its ports, that the deposits of the Cayster must have filled in a few centuries. They brought a multitude of pilgrims, that came to pay their devotions in the temple of the goddess; by the original arrangement presented by its vast dependencies and its colonnades, that was from the middle of the 7 th century one of the most imposing and most sumptuous of the edifices built by Greek architects.

Ephesus was then a religious centre in particular; but too many foreigners visited it, for it not also to be the seat of an international commerce that gave great profits. The road that descended the valley of the Cayster was one of t those most frequented among those, that from the high lands of the peninsula ended at the sea. Yet it was rather Miletus that had the great place for commerce, where the merchants had most enterprise and most daring in extendind the bounds of the field in which they operated. They could not extend in the depth of the continent; in their first steps, they struck against the Lydians and the Carians, warlike and well armed peoples.

In these lands it was their interest to arrange correspondents that should profit by sending them merchandize; this required only politics and perseverance. On the other hand, the sea opened to their ambitions a field that seemed to n have no limits. Was there any end to those shores, where t they saw extend and flee before them to north and south their irregular and broken line? Particularly when they turned to the north, they felt themselves attracted by all the promises and all the possibilities of the unknown. After having reached cape Sigeum step by step, the mariners of

Miletus pursued that way along the coast of Asia, and beyond the two straits that enclose another sea, that they named Propontis, they found another sea, which seemed as vast as the Egean sea, but which did not offer the same shelter to barks driven by the wind. There were islands in view, as if to mark the path; neither deep gulfs, coves nor protecting creeks. What they had before them on leaving the Bosphorus was a sea frequently veiled in fogs, between steep and straight shores, black with forests, and which extended infinitely toward the east and north, without one's being able to suspect at what distance were the coasts, that must bound it in those directions.

Neither the currents of the straits, nor the immensity of this sheet of water yet unexplored stopped the Miletans. Hugging the shores, going a little farther each year, they ended by reaching the end of that sea, even the feet of the snowy mountains of Caucausus. On the coast of Scythia they penetrated into the windings of those lagoons above which rise the hills and plateaus of the peninsula that they named the Tauric Chersonese, and everywhere they succeeded in forming relations with the barbarous peoples, that inhabit here the clear spaces and forests, there the ravines of the mountain, elsewhere the fertile plains yellowed by the cereals. At the end of a century, on that long line of coasts from the Hellespont to the mouths of the Phasus, then had founded about 80 agencies, many of whom must become important cities. Henceforth they were so well accustomed to that sea, where they could find everywhere resting places among friends, or compatriots, that they changed its name. At the first moment, when they stopped in hesitation at sight of that immense sheet of water, they had called it the Axeinos or inhospitable; later after forming the custom of frequenting these seas, it was the Euxine or hospitable sea.

The Phoceans followed the example of the Miletans; but they extended in a different direction; their bold mariners sailed to the West. They did not stop in the ports of Sicily and Italy, as Greek navigators usually did when they had made the western cape. They pushed on farther, across the wide basin separating the Italian and Iberian peninsulas, and went to reconnoitre lands where Greeks had never set f

foot before them, Sardinia and Corsica, Gaul and Spain; they formed commercial relations and established colonies there. It is known how one of these, Massilia, and today under the name of Marseilles is one of the most populous and most mercantile cities of the South of Europe.

The same Phoceans took an active part in another series of naval campaigns, another enterprise of colonization. When about 630, the Saite princes opened Egypt to the Greeks, who had supplied their cities with valiant soldiers, and had t thus contributed to consolidate the power of the new dynasty, the Phoceans were the first to profit by that permission together with the inhabitants of Chios, Clazomene and Teos; they had their place marked among the founders of Naucratis, that agency located on the Canopic mouth of the Nile, where was concentrated all the commerce that Asian Greece began to conduct in Egypt.[1] A little earlier and about the middle of the century, the Dorians of Thera that the Pythios of D Delphi ordered to send colonists into Libya, but if it is necessary to credit Herodotus, they could not find a pilot in the entire Archipelago, that knew the way to that country, and who would undertake to guide their ships thither.[2]

Note 1.p.308. Herodotus. II. 177.

Note 2.p.308. The same. IV. 151.

Yet men ended by reaching the coast, and from the beginning of the century Cyrene, the colony of Therians, was surrounded by other Greek cities nearly as prosperous; it became the capital of a little African Greece.

If the Ionic captains of Phocea carried their voyages of discovery even to the distant shores of Corsica, Gaul and Iberia, yet to the cities of European Greece fell the care of extending Grecian civilization to those of the coasts of t that continent, that had never been reached before. The two States which took the most active part in that movement were Chalcis and Corinth. Chalcis, the Greek Sidon, was enriched early by the working of copper mines of Euboea and by working in that metal; Corinth, whose location between two seas predestined it to be one of the principal markets of Greece. Other less important groups, such as the Megarans, the Achaians of the Egean, the Locrians and even the Laconicans, were associated in these undertakings.

Chalcis commenced to radiate to the North; it built even 32 cities in that triple peninsula, that Thrace projects to the South between the Thermaic gulf and the gulf of Strymon, which gave to this peninsula the name of Chalcidic, which it has retained till this day. About the same time, Corinth founded Potidea at the mouth of the Strymon. As for Chalcedon and Byzantium, they owe their origin to Megara, opposite each other on the two shores of the Bosphorus.

Corinth particularly had her eyes turned toward that Adriatic sea on which its gulf opened; it found a free space on that shore. Its first colony was Corcyra (Corfu), that is posted on the threshold of the unknown, at a little distance from Italy, and grew so rapidly as soon to claim its independence. The metropolis and its powerful colony no less agreed in scattering along the coasts of Epirus and of Illyria agencies, several of which like Epidauros and Apollonia were called to a brilliant future. In navigating the Adriatic thus, Greek sailors frequently perceived toward the setting sun the lands of Italy, either the lofty mass of the Garganos or the long Iapygian promontory, that terminates Calabria and extends North to the gulf of Tarentum. The sea is sufficiently narrow, that from the most distant ages, certain relations were established between the shores of t the two peninsulas, the Hellenic and the Italian, relations whose traces seem to be preserved in the Odyssey, and besides indications of various nature, are evidenced by the results of excavations made by Orsi in the Sicilian cemeteries; there were found Mycenaean vases and vases of Grecian fabrication with geometrical decoration; but these relations were quite differently active in the 8 th century. The Greeks had lost even then the memory of the distant date to which belonged the founding of Cuma in Campania; all that they knew was, that Cuma had long been the only city that represented in Italy the language of civilization of Greece. Cuma already had commerce with Sicily and had already taken root at Zancle (Messina), when the emigrants from Chalcedon in 736 landed at the foot of Mt. Etna; the city of Naxos, properly speaking, was the first colony that the Greeks of Hellas e established in Sicily. In the following year the Corinthians were better inspired and seized the largest and best port

that Sicily possessed. On the island of Ortygia and between the two basins separated by it, they laid the foundations of that Syracuse, which was called to become one of the greatest cities of the ancient world. Then will be made for it a domain in the fertil lands on the flanks of that volcano by the slow decomposition of its lava, pumice stone and ashes. Catanea and Leontini are peopled by the Chalcidians; Megara Hyblea is a creation of the Dorian city bearing that name. At the end of the century all the eastern side of the island is Hellenized; then ambitions are directed toward t the southern and northern coasts. Gela and Selinonte grow under the auspices of the Rhodians, and soon afterwards Gela becomes the founder in her turn; she has Agrigente as a daughter, that did not delay in surpassing her metropolis in wealth and power. In the same way, Syracuse built the ramparts of Acrae in the heart of the mountains dominating her country, to cover them as an advanced post, while on the n northern coast, colonists sent from Zancle established themselves at the mouth of the river Himera. There no longer r remains to the Sicules and the Sicanes, who preceded the Greeks in Sicily, only the mountainous plateaus of the interior, whose inhabitants will only adopt the Greek language and customs two centuries later. Mixed with tribes of unknown origin that are called Elymeens, the Phoenicians retain possession of the ports in the West and Northwest, from Lilybeum to Panormus, today Palermo; they will remain masters until the Roman conquest, yet not without the influence of the cults and arts of Greece also making themselves felt even in that region. Segeste was the principal city of the country of the Elymeens; now in the course of the 5 th century was erected there a Doric temple, that is one of the most beautiful ruins left to us by antiquity.

Note 1.p.309. G. Perrot. Un peuple oublie. Les Sikeles. (Revue des deux Mondes of June. 1897).

While was extended around Sicily this girdle of Greek cities, how did the less distant Italy escape that kind of invasion? Even before landing on the great adjacent island, the Euboeans had founded there Rhegium opposite Zancle, to make themselves masters of the strait that we term the beacon of Messina. Establishments of the same kind multiplied

in the caurse of a few years. This was on the eastern side extending north. Locres, whose name even indicates the origin, the Achaian cities of Crotona, Sybaris and Metaponte, that soon became capitals of small realms, where the Oenotrian and Oscan tribes lived under the supremacy of Grecian republics. Finally Tarentum, that although Laconian emigrants were its first inhabitants, owed to its fisheries, commerce and industry a wealth and luxury, that passed into a proverb. The western coast of the peninsula will attract t the Greeks less; yet one cannot forget cities like Elea, t that by their sages took an active part in the work of thought, or like Posidonia, i.e., Paestum, employing the name given to it by the Romans, erected monuments accounted among the masterpieces of Doric architecture.

Of the cities just enumerated, their names will be found in more than one page of this history; most of them will be cited for a certain edifice that they have erected, for a certain decoration of their squares or their temples. That these mentions may not reach the reader unawares, it is important to warn him, to make him sensible of the band connecting them with their metropolises, all situated in Asia Minor or in Greece proper, those cities scattered over so many different shores. If in spite of the distances intervening, all these cities remained members of the same national body, they no less formed distinct groups, each of which had its particular destiny and its original appearance. Especially during the course of the archaic age when were created the types, before certain rules were imposed by the ascendant of superior genius and by works without peer, art has its provincial schools, and like the language, what may be termed its provincial dialects. That is why we have been led to offer here a rapid sketch of the general movement of Greek colonization; but we cannot think of summarizing for this period, even in brief manner, the history of the principal States of Greece proper, Sparta, Argos, Corinth, Sicyon, Athens, Thebes, etc. This history is known and is everywhere given with the details comprised; we shall only here recall a few traits, those suitable to be presented to the mind to understand how and why a certain city has contributed more than any other to the elaboration of the types of

the sculpture and to the progress of the manufactures, in what sense its action is exerted and what special character has been impressed on their works by its architects, sculptors and painters, its potters and goldsmiths.

If there be one opinion generally accredited, it is that which depicts Sparta as only occupied by war and politics during the course of its long life, and which denies to it all culture, all curiosity concerning matters of the mind. It is contrasted with Athens; there was an absolute contrast between the two cities. Like all the antitheses between the two cities that one pretends to introduce into history, this is but halfway just. The Spartans were Greeks after all. The Achaian element entered for a great part into the constitution of the people of the State, who had their centre very near the ancient capital of the country in the middle valley of the Eurotas. Sparta seems to have been one of the first cities of Hellas opened to the Homeric poetry; it is related that Lycurgus invited there the Ionian rhapsodists. At the beginning of the 7 th century the lyric Eolian poetry with Terpander finds the same favor there; in the greatest national festival, that of Apollo Cameios, a place is assigned to a competition in music; there is the cythera with 7 strings, the invention of that master, that for the first time charmed by its "nomes" the ears of the Greeks of the Peloponessus. Soon afterwards the Cretan Thaletas being ordered to Sparta, then troubled by internal dessensions, to establish order there, caused music and poetry to contribute to his work. A little later about 620, for the Laconian virgins the Lydian Alcman composed his parthenies, and the ancients also cited the names of seven other Spartan poets, that about this time cultivated choral poetry. Finally, at Sparta the elegy with Tyrteus introduced its social role, when it intervened in the contests of the field of battle and in those parties, to excite and to calm the minds. A people so sensitive to poetry could not be indifferent to art, and in fact we see at the same epoch native sculptors like Gitiades, or foreign sculptors like Bathycles of Magnesia, employed to decorate by their works the sanctuaries of Laconia. This Laconian sculpture is also represented today by an entire series of funerary or votive steles, one of w

which has already been reproduced here (Fig. 143).

The Dorians being strongly established under the dynasty of the Temenides in the city of Argos at the foot of its impregnable citadel, had founded there a powerful State, with the aid of its ancient inhabitants dwelling there, Achaians and Ionians, whose history is especially that of an unceasing effort to dispute the primacy with Sparta. That hegemony as the Greeks term it, it conquered in the first third of the 7 th century under an ambitious and bold prince Phidon. Argos then subjected all the cities of Argolis and the adjacent islands, notably Egina; it had become in the way the capital of the Peloponessus. It lost this supremacy on the death of Phidon; but there remained of it with the eternal desire of restoring it, the system of weights and measures which this sovereign had introduced in the peninsula, a system with which was connected the creation of silver money, the first struck in European Greece (Fig. 147).

At Corinth as at Argos, the Dorians by the right of the sword held a predominant place in the State; but their kings had an interest in guarding and protecting artisans and merchants, who by the opportunity of the location continued t their traditions of the ancient Phoenician agency. Under t the dynasty of the Bacchiades from the 9 th to the 8 th centuries, then during another century under the intelligent direction of the oligarchy that succeeded the abolished royalty,,prosperity did not cease to develop, and it attained its climax from 657 to 585 with the two tyrants, Cypselos and his son Periander; without always attaching an unfavorable idea to this term, the Greeks so called the party chiefs, that popular favor had invested with a power, that did not rest on hereditary privileges, was not defined by the laws, and was maintained only by the personal prestige of him that had seized it, and by terror when this prestige w waned. Sliding on rollers, the ships that scaled at Corinth passed from one sea to the other by the route called the d diolcos. The merchandize that they brought and were loaded with was the source of wealth. Corinth was also not merely a mart; like Tyre and Sidon, it was a centre of production. There were made fine woolen fabrics that the shuttle and d needle ornamented by varied designs; there were carved ivo-

ivory and metal; the bronzes that were cast there and chiseled there were sought everywhere. Pottery is one of the wares most appreciated by the peoples, that do not know to shape and burn the clay; it is perhaps that which they demand most insistently from the civilized men that supply them. The Corinthian potter had assured markets on the coasts of Thrace and Illyria, Italy and Sicily. He commenced to work for those barbarians or semi-barbarous patrons. To him was even attribsted the invention of the wheel. The error is manifest, for the Mycenaean ceramists were already skilful turners; but it no less attests the activity of those workmen and the reputation that they enjoyed. They did not long content themselves with making common pottery; it must be about the first years of the 7 th century, that there began to leave their workshops those painted vases with a reddish violet decoration, that appears to have enjoyed for long years an extraordinary vogue in the Grecian world and even outside its limits. Ships carried them by full cargos, and they are found today, not only in the cemeteries of Rhodes and the other islands of the Egean sea, but also in greater number in those of Campania and Etruria; they are even found as far as Carthage. To protect its merchant marine in those parts of the Adriatic where piracy always prevailed, Corinth provided a war navy; she constructed the first triremes. The public edifices of the city were in accord with its opulence; it is stated that at Corinth for the first time a pediment crowned the facade of the temple. After the death of Periander, when the tyranny was abolished (582), the colonies of Corinth escaped from the domination of their metropolis; but they no less continued with it commercial relations, and in spite of that injury to its power, Corinth continued to be in Greece one of the first States of the second rank, by its exceptional location, its commerce and industry.

Sicyon, the neighbor of Corinth, did not possess the same advantages; but in spite of the smallness of its territory, that city no less made a very great figure under the dynasty of the Orthagorides. No prince more strongly affected the imagination of his contemporaries than the last of those tyrants, Clisthenes, who reigned during the first quarter of

the 6 th century; he daqzled them by his vast fortune and by the liberal use that he made of it, as well as by his v victories in the great games of Greece. The treasury of Sicyon at Olympia bears witness to the munificence of the Orthagorides; we shall have occasion to mention that monument.

The Dorian element dominated at Megara. If that little S State proved its vitality in undertaking to people the shores of Propontis, it does not seem to have contributed to the progress of sculpture. Yet it had its treasury at Olympia, which presents curious peculiarities.

Quite otherwise at that epoch is the importance of Athens, that we have already seen in the preceding period prelude by the originality of its ceramics, the great part that it will play in the evolution of Grecian art. If in 683 the magistrates had become annual, the Eupatrides were still the only ones having access to those offices; but henceforth A Attica containned an entire people of laborious cultivators and of skilful artisans, that demanded a less partial justice, who were indignant at seeing nearly all the land in t the hands of the nobles, and who bent under the load of debts contracted with those rich proprietors. There is elsewhere, in this discomfort and these complaints of the multitude, there was a temptation for the ambitious, that desired to aspire to the tyranny. Cylon failed, and the legislation of Solon seemed to solve the social question without violence (594); but it allowed to remain too much covetousness and bitterness for a new legal order to establish itself immediately, end if it continued to regulate civil life, it did not prevent Piisitratus, a descendant of the Nelides kings, from taking possession of the power. With interruptions, he governed Athens from 560 to 527; his sons Hipparchus and Hippias succeeded him; they were driven out in 510.

In the history of art and particularly of Attic art, there is no period more memorable than those 50 years of the reign; there is none better calculated to make felt on this area the effects of the intelligen and thoughtful will of a chief of State; perhaps in all justice, it would be better to speak of the age of Pisistratus, than of the age of Pericles. Under Pisistratus and his heirs, Athens suffered a profound transformation. Untel then it had lived within itself and

rather isolated; it was less open that Sparta to the external influences, to those of the ideas and arts of Asian Greece. During his two exiles, Pisistratus had lived abroad; he had formed relations with the cities of Eolia and Ionia, with the tyrants of the Cyclades. Once uncontested master of Athens, he invites there at the same time as the rhapsodist possessors of epic poetry and the contemporary masters of the lyric song, the Ionan sculptors and the workmen accustomed to cut white marble supplied by the islands, where Lygdamis of Naxos, his lieutenant and friend commands. By his orders a sort of scientific commission collects the old epic poems, and first commits the text to writing. Recitals, competitions in musci and poetry are included in the national panathenaic festival, to which Pisistratus gives a splendor unusual before. He also enlarges the rustic festivals of Dionysos, from which soon came the tragic and comic churuses. At the same time he changes the appearance of the city, that until then had been only a great market town. He brings there an abundance of water from the neighboring mountains, commences the erection of eodifces of all kinds, monumental f fountains, gymnasiums, porticos, altars and temples. In the plain, he lays the foundations of the colossal temple of Zeus Olympios, that would only be completed six centuries later. He has established his residence on the rock of the Acropolis, where he builds other sanctuaries ornamented by reliefs and statues. The temple of Athena, whose arrangement has c been revealed by recent excavations, is like a first sketch of the future Parthenon. Whatever part that these foreign artists could take in his enterprises, the Athenians profit with ardor and success by the lessons that are given to them. Then is born that Attic school of sculpture that was p promised such an elevated destiny.

The course of these creative faculties was also favored by the democratic movement that followed the expulsion of the tyrants and by the unexpected energy with which the freed city defended its independence against the coalition of the Spartansl Chalcidians and Thebans. Sculpture will find its themes anf happy inspirations in these joys of the liberty recovered from the nobles. Thus will be erected at the entrance of the Acropolis the statues of the two slayers of

the tyrants) and on a terrace of the plateau those that represent the eponymous heros of the ten new tribes. A guadriga of bronze will perpetuate the memory of the victory obtained over the Beotians and the Chalcidians.

This display of strength and of fruitful life is not then an isolated phenomenon in the Grecian world; little States present a scene as interesting. The island of Egina in the Saronic gulf has only a small area, without water and sterile. Its inhabitants, since they had ceased to be dependant on Argos and Epidauros, were no less enriched by commerce and industry. They had light triremes with selected crews, that convoyed their merchant ships. They fashioned clay and exported pottery. Their sculptors were celebrated for their skill in proportioning the elements of bronze, in casting it in moulds and chasing it; they also knew how to cut marble. Spared by time, the temple dedicated by them to Athena is one of the monuments of which will be most frequent mention in these pages. Until its ruin, it presented one of t the best preserved types of Doric architecture that one can have, and the figures that decorated its pediments form the most beautiful entirety left to us by archaic statuary. Egina, "that spot on the eye of the Piraeus," was too near the shores of Attica for there not to be between the two States a jealous rivalry, that frequently broke into declared hostility. Egina must end by succumbing in this unequal duel (455); but it was an honor for it to have held Athens in c check for more than a century, and especially for having shown its emulation not only as a naval power, in opposition to the Persians on the day of Salamis, but also in the domain of art, as the native land of Kallon and of Onatas.

Although their vast and fertile territory nourished a population very superior in number to that of an island like Egina, the Beotians count less in that epoch of the history of Greece. The principal city of that country, Thebes, was particularly occupied in ensuring its supremacy iver the o other Beotian cities, but had no very high ambitions. We s shall scarcely have to speak of it, at least for this entire period, except in relation to a secondary brance of art. Like Attice, Beotia furnished an excellent plastic clay; its potters produced vases lacking neither elegance nor original-

originality; but so to speak, nothing remains of its edifices, and one does not see otherwise, that what it built was much admired in antiquity, nor that it had a school of sculpture which belonged to itself; it was contented to attract and employ Ionian and Athenian masters.

This cannot be the place here to recall even very briefly, why and how began that long struggle between Persia and Greece, that commenced at the ending of the 6 th century by the revolt of Ionia, and ended nearly two centuries later with Alexander and the conquest of Asia; but we must indicate the reasons that have decided us to fix as the limit of the archaic period the date of the battle of Platea (479). This victory of Hellenism forever drove the Persians out of Europe. The slowness of this almost unhoped for deliverance as it were intoxicated the Greek spirit; it gave that a prodigious impulse, and confidence in itself without limit, t the full assurance of its superiority, both native and acquir

Particularly Athens in that crisis was conscious of its genius. Between Marathon and Salamis, Athens was docile to the advice of Themistocles, became the first naval power of Greece, and had 200 galleys afloat when Xerxes crossed the Hellespont. On the morrow of the triumph, it emerged from its narrow frontiers, and created its maritime empire; the resources supplied by the tributes of its allies, it placed at the disposal of artists of genius, which it charged to decorate the city that had become the true capital of Hellenism, "the Greece of Greece," as said the poet. The architects will employ the white marble of Pentelicos, that they will work nith marvellous care, for constructing edifices that will remain the most finished examples of the Doric and Ionic orders; the sculptors and the painters will give to the lines of the human figure a nobility and a purity hitherto unknown. Art will be fully emancipated; all trace of naive conventions and of ancient restraints being effaced, it will use the materials with full liberty to express its ideas by forms, that will be their clear and perfect expression.

CHAPTER III. GENERAL CHARACTERISTICS OF THE ARCHIT

I. The Materials and Construction.

From the 8 th to the end of the 6 th centuries the Greek architect continued to use the materials employed by his predecessors of the Mycenaean age, and he used others furnished to him by a more advanced industry, or that the desire of impressing on his structures a more marked character of nobility and elegance suggested to him the idea of taking from the mountain slopes.

Hawing the nature of the soil of Greece, where the rock, when it does not project, is only covered by a thin layer of vegetable earth, the constructor finds everywhere at his command an excellent stone for buildings; he has only the embarrassment of choice among the different varieties of l limestones, marbles and sandstones, that form the framework of the Hellenic peninsula and of the islands lying around it.

In Attica alone are counted no less than seven different kinds of stone, that from the primitive time until the Roman epoch have entered into the composition of the edifices of Athens and its suburbs.[1] Thus in the course of that period the architect renounces tamped clay, crude bricks, little materials with their size concealed under plastering; he rarely employs them further, at least in those of his structures to which he desires to give the character of works of art. He builds with cut and jointed stones. Calcareous tufa, a tufa more or less compact and hard, according to the quarry from which it came, is almost the sole material that he uses in Greece proper and its colonies until the time of t the Median wars; yet already about the end of the 6 th century he commences to make use of marble, at least in certain parts of the edifice to which attention is more particularly directed.

Note 1.p.319. G. R. Lepsius. Griechische Marmorstudien. Berlin. 1890. p. 114-125.

Among the rubbish of the temples of Pisistratus and his sons erected on the Acropolis of Athens, one finds in the state of fragments cymas and coronas either made of Pentelican marbel or of coarse-grained marble furnished by Paros and Naxos.[1] Also in that marbel from the islands were cut t the tiles found with fragments of the cornice, and that must

have formed the covering of the same edifices.[2]

Note 1.p.320. Ant.Denk.d. d. Arch. Inst. I, pls.38,50.

Note 2. Lepsius. Marmorstudien. p. 123.

Near these details the stone of the Piraeus forms not only the foundations, but also the visible mass of these buildings; one recognizes there the "acntites lithos" of the ancients, so-called from presenting everywhere the same appearance and the same density; it contains many little shells in places; but it no less lends itself to very fine cutting and to the execution of mouldings; it resists storms well.

Sicily, where so many great temples were built, had no stones equaling those of Attica. Marble was entirely wanting there, and the tufa is of very loose texture, pierced by l large and deep cavities near together. It was then necessary for obtaining surfaces apparently smooth, to cover the stone everywhere by a very thick coat of stucco; the form there only received all its fineness by means of that covering, on which the decorators have applied their colors. This stucco also serves as a protection for the surfaces that it covers; when at length it is detached from the stone, that is very quickly attacked by dampness. Never have I ever seen anything in Greece, that resembles the two columns of the pretended temple of Artemis at Syracuse. Judging from their outlines and their proportions, they must be nearly contemporaneous with those of the archaic temple of Corinth; but what a difference in appearance! The columns of Corinth have been exposed to the air for about 2500 years, but have retained the roundness of their shafts, and in a certain measure the distinctness of their profiles; those of Syracuse appear as if wormeaten; they give the impression of rotten wood.

Not alone by the application of stucco were remedied the defects of the stone; men also employed therefore a material, terra cotta, from which the industry of primitive Greece had not required that kind of services. As proved by its c ceramicsl,that knew how to burn pottery in a great heat; b but it had not thought of creating by the same procedures, materials to form the body of the structure, that would aid the architect to cover and decorate its surfaces. Among the ruins of the edifices of Mycenae and Tiryns have been found

neither burned bricks nor clay tiles; only after the Dorian invasion were kindled the kilns of the brickmakers. When on the temple was substituted the gable roof for the terrace of tamped earth of the Mycenaean megaron, it was necessary to find for the two slopes a mode of covering impenetrable to rain.

With the variety of forms given by the mould and the facility it gave for reproducing the same type in an indefinite number of examples, the tile offered the means of attaining the desired result without great cost. The roofing of the temples of the archaic age was then made of tiles. It is already so at the Heraion of Olympia, and it is the case for all the great temples of Sicily, to which in particular we owe our knowledge of the methods of the architects of the 6 th century. If in Greece proper, in the country that could easily use the manufactures of Naxos, there were exceptions, these were in small number. Elsewhere were edifices of smaller dimensions than those to which belonged the marbel tiles that have been found in the layer of rubbish caused by the sack of the Acropolis of Athens in 480.

Once the habit was thus adopted to profit by the facility of fabrication presented by terra cotta, and its marvellous qualities of resistance and duration, men were not satisfied to employ it as an element, as an integral part of the construction; the architect also utilized it, especially in Italy and Sicily where the tufa was coarses, to decorate certain parts of his buildings, such as the ceilings and entablatures, he faced the cornice with it, or he erected clay antefixas at the apex and angles of the pediment. The colors which fire had incorporated with the clay were far more solid than those applied by the brush on the plastering or on a slab of stone. Time has permitted to remain only very few vestiges of the ornaments that the brushes of the most skilful workmen of Athens traced on the marble of the Parthenon or of the Erechtheion; on the other hand, the plates of colored clay gathered among the rubbish of various archaic edifices best give us the idea of the polychrome decoration of Grecian temples.

If under the form of tiles and of facings, terra cotta has played a notable part in the arrangement of the temple, it

has not entered in the form of bricks into the composition of the walls.

Faithful to the Mycenaean tradition, the architect of the old temple of Hera at Olympia in the 8 th or 7 th centuries had still built its wall of crude bricks placed above a substructure of cut stone; but in the 6 th century that mode of construction was renounced everywhere, and bricks dried in the sun were not replaced by bricks burned in the kiln; that was by stone. When men occupied themselves in ensuring the duration of the house, in which they believed the protecting god of the city to be received and lodged, the use of stone was imposed. Supports were necessary for sustaining the roof of the external portico, and where these supports were exposed to storms, wood being fragile and perishable risked soon failing in its task. Now the burned bricks could not replace it in that function; we have seen what complicated arrangements men had been compelled to make in countries where, as in Chaldea for lack of stone, they had been led to wish to construct columns of bricks. Brick was still less suitable for architraves; by reason of its small dimensions, it did not lend itself to cover spaces unless cut in voussoirs, when it enters into the composition of the vault. On the contrary, the shaft of stone, the beam and slab of stone replaced with advantage the trunk of a tree, the timber and plank. There remained the wall, that one could rigorously retain as it was in the temple of Hera, of clay bricks; but the use of stone for the column and entablature led also to substitute it for bricks in the walls. When the edifice was entirely made of the same material, of the best tufa supplied by the neighboring quarries, there was a unity of appearance, that could give at the same time a guarantee of solidity. A wall of stone jointed with care has its own beauty and contributes to the effect of the whole.

We have cited some sanctuaries built of bricks, that are regarded as very ancient;[1] but those were simple chapels without external or internal colonnades, and that do not merit the name of temples. The temple was an edifice of stone, wherever characterized by the Doric or Ionic order. On the other hand, men continued to employ bricks in other kinds of buildings. Thus there was at Epidauros a portico of

brick, called the portico of Cotys; half ruined, it was restored in the second century of our era.[1] A part of the walls of Athens and all of those of Mantinea were built of the s same material.[2]

Note 1.p.322. Histoire de l'Art. Vol. VII, p. 70.

Note 1.p.323. Pausanias. II, 27, 7.

Note 2.p.323. Vitruvius. II, 8, 9; Pausanias. VIII, 8, 5. On the walls of Athens, see inscription No. 167 of C. I. A Att. Vol. II, part I, as well as the work of M. Choisy, Les Murs d'Athenes d'apres le devis de leur restauration, in E Etudes epigrapniques d'architecture grecque; 1884. Vitruvius also cites (the same) the cellas of two temples of Patras; the walls were there of brick; the columns and entablature were of stone. He finally mentions as great edifices entirely made of bricks, the palace of Croesus at Sardis and that of Mausolus at Halicarnassus.

Inversely from the Roman constructor, the Greek constructor seems to have used burned bricks only exceptionally. T The chapels, portico, city walls that we have seen, were of crude bricks. Men knew how to make bricks hardened in the fire of the kiln; what demonstrates this are the epithets "ome"or "ople" that the authors attach to the word "plinthos" according to circumstances; but when that is accompanied by no adjective, it appears to designate crude bricks, that were in more common use, and nowhere is mention made of an edifice whose body was formed of burned bricks. Yet in Greece men had more than one occasion to take into account dangers run by every structure executed in clay bricks dried in the open air. Cimon and Agesilaus took Eion and Mantinea by turning against the walls surrounding those cities, here the waters of the Strymon and there those of the Ophis. Pausanias says in this respect, "bricks melt in water as wax a melts in the sun." It was thought that this defect was compensated by the advantage offered by that compact mass, by not breaking off in pieces like stone under the blows of the battering ram, but by deadening them while yielding. There is truth in that observation; but what especially explains this preference for the use of crude bricks is the power of custom, the rapidity and cheapness of the procedure. Yet today in Greece, if in the mountains the house of

the peasant is usually built of pieces of stone, it is most frequently constructed in the plains of clay bricks among which are inserted wooden timbers.[3]

Note 3.p.323. Dörpfeld. Der antike Ziegelbau und sein Einfluss auf dem dorischen Styl. (In the volume, Historische und Philogische Aufsätze Ernest Curtius zu seinem siebenzigste Geburtstage gewidmet. 1884. p. 139-150.

If in compact construction wood continues to be used in the form of ties, and if men are compelled to resort to it to protect the ends of walls, to surround and enclose all openings, the part that it plays in architecture loses its importance, when is developed a taste for construction of dressed stone. In the temple of Hera it furnished the material of the supports, entablature, antes and the enclosures of the openings; but the walls of that edifice were of crude bricks. In the more ancient temple of Locres, that is dated in the 7 th century, the antes seem to have been wooden timbers.[1] In the 6 th century in the stone temples, wood scarcely serves more than to compose the carpentry of the roof. Yet it is still employed in houses to form the enclosure of doors and windows; this is divined from the nammen in which these are represented on the painted vases.

As for metal among the Greeks, it never took the function of a support in the building, or of a timber.[2] The architect used it only as a means of tieing, in the cramps and anchors that fasten together the stones of a jointed wall and the different members of an entablature.[3] For metal coverings, we shall have more than one occasion to mention them; a general observation will suffice here. They must have been placed on wood in the first place; they protected it efficiently against storms, and at the same time lent themselves to receive quite varied ornaments; they offered contrasts and very happy harmonies of tones.

Note 1.p.324. Petersen in Römische Mittheilungen. 1890. p. 171.

Note 2.p.324. The Romans appear to have known metal frameworks, although they made a very limited use of them. (Vitruvius. V. 10, 3). See Ch. Normand, Essai sur l'existence d' une architecture metallique, in Encyclopedie d'architecture. 1883.paris, Morel.A letter of Laloux in Revue archaeoligique.

1885. p. 327-399; also Ch. Normand, L'architecture metallique, ou role de metal dans les constructions antiques. 1885. p. 214-228 of the same.

Although he built in stone, the architect of the classical age avoided the renouncing the renouncing of the very varied uses that he could make of metal, in using it to cover certain areas and to better determine the projection of a certain moulding; for example, he did that in the temple of A Athena Chalciecos at Sparta; but he will employ that metal with more discretion than did his predecessor, the architect of Mycenae he will not lavish it as he did, in coverings of natural or gilded bronze, in connecting pieces inserted everywhere with ostentation. If the part assigned in the whole of the decoration to the metal is thus restricted, this phenomenon admits of a double explanation. There is a sort of natural affinity between wood and metal; the wood seems to require the metal as its necessary complement; now in the 6 th century the wood no longer occupies in the edifice the place that it formerly held. At the same epoch the ceramist places at the disposal of the architect those plates of terra cotta, which cost much less than bronze and are not less durable; one comprehends that they may have had the peeference, from the day when the industry was prepared to deliver them in indefinite quantity, and when the painter knew how to ornament them with designs whose vivid colors did not r risk being killed, either by the flow of the rain or by the rays of the sun.

2. Masonry.

The Greek mason knew lime very early; but he employed it only as a coating, as plastering; he never used it to compose a mortar for connecting together the elements of the w wall.[1] In the masonry that we have termed Cyclopean, for example, that of the wells of Tiryns, a clay mud was mixed w with straw or hay and inserted between the irregular blocks and the little stones that fill the intervals. That earth filled the holes; but it had no tenacity. Soon soaked by r rain, it left voids everywhere. To form a wall with all its members only forming one body, there was then nothing to c count on in such a rude method of connection.[2] They did not attempt to seek a rapid and strong setting mortar, that with

advantage would replace that wet clay; from the time that they renounced the use of greatmaterials, they adopted the method of setting the stones dry. These adhered together only on their surfaces well dressed with the tool, and in the s structures of the best epoch, care in dressing and facing will have been carried so far that the joints will become almost invisible; that is notably observed on the noble structures on the Acropolis of Athens. That result was obtained by an ingenious artifice. In the vertical and also sometimes in horizontal directions, the blocks touch only at t the outer edges along a narrow band enclosing a surface slightly sunken. By this limitation of the joint surfaces, t they were able to give to these a polish, difficult to obtain so perfectly over the entire area of the surface.(Fig. 148). It is further unnecessary to believe that they waited until the 5 th century to adopt an arrangement of this kind. Already on the old temple of Hera in the stone substructure that formed the base of the wall, the mason practised that relieving of the courses; but he did it with less art and in coorer conditions. No regular chiseling with a regularity sufficient to maintain a sufficient plane of contact between the two beds; the stones are hollowed in a concave l line and only touch at their edges. Too thin, this sort of lips are liable to break under the stress. From the succeeding age, men learned by experience to give them the necessary thickness.

Note 1.p.325. Histoire de l'Art. Vol. VI. p. 481.

Note 2.p.325. The same. p. 483.

The city walls had several courses in width with a very marked batter; the courses broke joints. Men thus believed that they had done enough to ensure solidity of the wall, when by a cutting diligently executed, they had established between the opposed faces of the masonrw a contact as p perfect as possible; but it was not the same there as in the temple, where the wall was much thinner, and where by reason of the function that they fulfilled, certain stones found themselves set to overhang. To prevent all movement there, all displacement of the materials, and to connect t them more intimately, they had recourse to mechanical connections, to cramps of bronze or iron, set in cast lead that

protected them from dampness. It is curious that the precautions takin to consolidate the masonry had the final result of hastening its destruction, from the moment that these edifices ceased to be maintained and passed into a state of ruin. There in a breach, where the lead covering was exposed and ended in being pierced, the iron increased in volume by oxidation, and caused the fracture of the stone around it; but what caused still more injury in many places was the w work, that in times of misery the inhabitants of the humble villages undertook, which had replaced the ancient cities. The least bit of metal had its value for these poor people; they broke open the wall to remove this ironwork.

From the end of the Mycenaean age, they ceased to construct with merely rough blocks, such as are found in the walls of Tiryns. That method had something rude, almost barbarous; it did not make sufficient difference between the works of nature, that sometimes piles up those rough blocks of stone, and thus of man, where he loves to impress the mark of his will. During its golden age, Grecian architecture will not seek elsewhere to astonish the eye by the enormous size of the materials employed; if some wrought stones do not fail to present exceptional dimensions in some edifices, that is because they were demanded by the necessities of the construction. For example, such will be the case for certain monolithic columns, for certain architraves that have to cover great spans. Now one has by this reason to say, that the c constructor did not tend to use great stones. The effort t that these represent is especially muscular strength; for that reason it remains in an inferior order. What characterizes the masonry of which will consist the edifices that we have to pass in review is, that it it is almost entirely composed of materials, that owe to their moderate size the advantage of allowing themselves to be easily dressed in t the quarry, to be readily transported and hoisted; these m materials of moderate dimensions lend themselves best to serve the designs of the architect.

One can consider the wall from two points of view, on the one hand being the appearance that it presents to the spectator that sees only its external faces, and on the other being its internal construction , only revealed where an

accident has breached the crest or torn the side. It is proper to commence with what one sees at first, when he finds himself before a fragment of an ancient wall, and the eye measures its height.

Among the different types of masonry that one finds in t the buildings of the archaic period, if any one of them seems to give the impression of high antiquity, it is that termed polygonal masonry. It has sometimes been confused w with Cyclopean masonry; but it differs prfoundly in that it already assumes in the stonecutter a certain professional skill, and particularly that its joints are sometimes as fine and close as in masonry with regular courses (Fig.149). What characterizes it is, that the stones composing it are but exceptionally prisms; many among them present surfaces that take the form of an irregular polygon, a pentagon or hexagon with unequal sides; no two in a piece of wall are exactly similar in dimensions and contour. By their reentrant angles, they are indented into each other, the term that best defines the appearance of this masonry would be that of indented masonry. The mass so constructed owes to that indenting, that locking together of the materials, an extreme solidity; thus it is employed by preference for retaining and city walls, particularly in parts near the gates most exposed to the attacks of the enemy. (Fig. 150). That is why in certain works our engineers today freely make use of masonry of that kind.

Ordinarily a broken line bounds the visible face of each block; but a curious variation from the traditional type is furnished by the powerful wall, that supports the terrace on which was built the temple of Apollo at Delphi. There t the network outlining the joints on the entire field of the broad surface is not composed of s.raight lines as elsewhere all the lines composing that network are curved with the most capricious windings. (Fig. 151). That preference accorded to curved outlines complicated the work of cutting. Did it mive to the whole a superior resistance? I do not know; yet this wall with its slightly projecting footing has always marvellously fulfilled its function, in spite of the enormous thrust against which it must contend. Probably built in the 6 th centurn, it still stands in its entire ext-

extend for a length of about 295.3 ft. and with a height of more than 9.8 ft.

In the appearance of a wall of polygonal masonry is a sort of incoherence, even where the work has been most carefully executed, an apparent confusion that perplexes the eye; in vain it seeks lines that accord with the principal lines of the monument, which are either parallel or penpendicular. The Greek mind with its innate taste for order, for what it called the "cosmos," must be especially sensitive to that defect; thus one sees early, from the time when were built the ramparts and domed tombs of Mycenae, a very marked tendency appears toward horizontal beds of courses. By adopting that mode was realized a notable economy in labor. In polygonal masonry it is necessary to make each stone separately, that fits only a single place; on the contrary in masonry with regular courses, all the stones cut on the yard may be substituted for each other in nearly all parts of the building.

Yet it was scarcely possible for one to attain perfect regularity at the first attempt; time was required for the workmen to accustom themselves to impose on the materials a form and dimensions, that in each structure were similar for all elements of the wall. Between the polygonal and the most regular isodomum is what one could term transition masonry, in which the beds of the courses are horizontal, but certain end joints are oblique and where indents have not been avoided; not having been cut to exact measure, more than one stone encroaches on the adjacent course. For example, this is seen in a wall of Isionda in Pamphylia, that also presents another curious peculiarity; very low courses alternate with others that are higher and recall the wooden ties of primitive structures (Fig. 152).

From one experiment to another, perhaps from the 7 th century they came to practise that kind of jointing, which henceforth was almost solely employed in the construction of edifices such as temples, and which will even be applied to city walls; this is the isodomum of Vitruvius; it is what moderns term Hellenic masonry. In this system, if certain courses are sometimes higher than the others, all stones in the same course have exactly the same height, without always being of the same length. The joints of the upper course

there always fall near the middle of one of the stones of the lower course, an arrangement that has the double advantage of better ensuring than any other the stability of the masonry, and at the same time being agreeable to the eye. (Fig. 148). By the beautiful symmetry which prevails there, this masonry affords entire satisfaction to the mind of the spectator, to which is thus recalled the idea of the master of the work, who regulated the arrangement of the entire edifice.

One would be tempted to believe at the first moment, that polygonal masonry is more ancient than masonry with regular courses, and to assign thereby a later date to all edifices in which it appears. This would be an error. Taking it where the joints have the same precision as those of the isodomum and where the execution is careful, it is not in itself a mark of high antiquity. The work is as complicated as that of the isodomum; in a certain sense, it is greater. The truth is, that both kinds of masonry came by the same advance from that masonry which we have termed transition masonry, where the hand of the stonecutter is still uncertain and hesitates between the two types. In time this ended in separating and clearly defining themselves; each of them found its use in structures of different character. The polygonal was scarcely used for edifices, properly so-called. Exceptionally it is found in temples, as in the cella of the temples of Rhamnus, which are probably earlier than the Median wars.

What proves that the presence of polygonal masonry does not suffice to date an edifice is, that this masonry is found in certain structures superposed on the most correct isodomum; for example, this is the case in several edifices of the Greek city of Cnidos in Asia Minor (Fig. 154).[1] It is employed concurrently with the isodomum in Lycia in a building, the public baths, that according to the evidence of an inscription was entirely built "from the foundations" in the first century of our era.[2] In the walls of Cnidos, this same masonry encloses vaults with voussoirs of very good execution; now we know from Thucydides that Cnidos was destitute of walls in 412, so that the Athenians failed to take it by surprise.[3] The enclosure is very well preserved, that surrounds the ruins of that rich city, and thus cannot be

there always fall near the middle of one of the stones of the lower course, an arrangement that has the double advantage of better ensuring than any other the stability of the masonry, and at the same time being agreeable to the eye. (Fig. 148). By the beautiful symmetry which prevails there, this masonry affords entire satisfaction to the mind of the spectator, to which is thus recalled the idea of the master of the work, who regulated the arrangement of the entire e edifice.

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earlier than that date, and the place occupied there by the vault would rather make it thought to be of the Macedonian time than of the 4 th century. At the other extremity of the Greek world in Acarnania, the isodomum and polygonal masonry were employed indifferently in the walls where the entire construction appears to be of the same epoch.[1]

Note 1.p.332. Texier. Description de l'Asie Mineure. Pls. 160, 164.

Note 2.p.332. The same. Pl. 207.

Note 3.p.332. Thucydides. VIII. 35.

Note 1.p.333. L. Heszey. Le mont Olympe et l'Acarnanie. p. 393.

In Cyclopean masonry the external faces of the stones were uncut or scharcely dressed. When the elements of the masonry diminished in size, and they all received a dressing appropriate to the places that they must occupy in the entirety, men occupied themselves in cutting smooth the visible faces. This work was carried still farther in the isodomum than in the polygonal masonry.

The materials for the construction of masonry only received on the stone-yard an incomplete and temporary cutting. "The beds and joints alone were completed in advance, and the face remained, if not rough, at least very roughly hewn. The entire surface must be dressed off in a general facing, and that last operation was done without any chance of error and without experiment, because care had been taken before setting to incise on each block directing lines defining the form of the face with entire accuracy."[2] For example, this is observed on the imperfectly finished structures of the south wing of the propyleion of the Acropolis of Athens. There below courses with entirely smooth faces are others where the directing lines enclose a field on which the stone is merely roughed. The projection of the boss must be cut away in the course of the facing dressed in place, and the entire face of the wall be brought to the plane of the chisel drafts along the joints. On the contrary, if one desired to avoid the slowness of the recutting in place, the continuity was frankly interrupted, and recourse was had to sunken joints or to masonry with successive offsets (Fig. 159). One also notes on these panels projecting tenons at about

the middle of each stone. "These tenons aided in moving the block, or rather they marked the thickness of the stone removed in cutting; these were so many means of hoisting, so many proofs serving to fix the basis of the payment due to the workman."[1]

Note 2.p.333. Choisy. L'art de batir chez les Romains.p.102

Note 1.p.334. The same. p. 111.

At least until the 5 th century the architect was not accustomed to preserve these auxiliary projections, those of the bosses surrounded by a draft and those of the tenons; they were reserved in view of the services that then could render; once becoming useless, they must disappear; where they remain is because the structure has not received the final touches. Very much later, what was at first merely an expedient was changed into a decoration. The sight of n numerous edifices where the work was interrupted accustomed the eyes to the temporarytemporary forms. Even in their antiquity, these found a sort of consecration. Hence arose t the different sorts of bosses with a variety of chisel drafts enclosing their projection, and the tenons being sometimes cut with diamond points became ornaments, that seemed to give a more robust appearance to the face of the wall.

Note 2.p.334. The concave line here representing the pavement of the cella is taken from a drawing by Durm. (Handbuch, Fig. 48).

The simple and frank taste of the archaic art did not know those refinements; yet one also finds in the monuments of that period a certain arrangement not explained by the effect of habit. Here is an example. If on enclosing walls the masonry is similar from top to bottom, it is otherwise in the walls of temples. There between the lowers of the courses forming the wall and the area on which that wall rests is an interval, that is filled by a row of great slabs set on edge, a series doubled in thickness. Much higher than t the stones with coursed beds, these slabs project 0.32 to 0.39 in. from the face of the wall (Fig. 156). By their dimensions as by their slight projection, the slabs in question are then clearly distinguished from the masonry above them, and thus they form a sort of continuous plinth on the lower part of the wall. We have already given the reason f

for this peculiarity, when we sought to show what influence the architecture of the Mycenaean age exercised on that of the classical age.[1] We said that one could scarcely see in that arrangement more than a memory of the stone substructures, that in structures with bodies of crude bricks, were always interposed between the damp earth and the clay mass, only a memorial also of the facings of heavy slabs of limestone or of thick planks, which protected the part nearest the ground, where the wall was made of small materials.

[1] Note 1.p.355. Histoire de l'Art. Vol. VI.p.729. Fig. 321. Otherwise Dörpfeld, we believe, first gave this explanation. (Der antike Ziegelbau und sein Einfluss auf dem classischen Styl).

The arrangement of the materials in the interior of the wall comprises no less variety than the aspect of the exterior. It is necessary to distinguish between the walls on which falls the task of resisting violent thrusts, like retaining walls on the one hand, and on the other, those like the walls of the cella of the temple, that only have to bear the upper parts of the edifice. The first must necessarily be thicker. They are not everywhere constructed in the same fashion, and this is verified at Assos, where the great Doric temple and the fortifications of the city appear to date from the 6 th centurw. The enclosure is built in regular courses. In places the wall is made of stretchers and headers alternating in each course (Fig. 157). The headers extend through the entire thickness of the wall; the inside faces of the stretchers do not touch but leave a space between them. Above the entrance gates, whose lintels it is important to relieve, the arrangement changes. Headers only recur in every third course; the voids thus occupy more space than in the masonry. Elsewhere that the wall is more massive and has a thickness of 9.35 ft. it is entirely different; the through stones are omitted, to which it would have been necessary to give unusual dimensions; the faces are made of stretchers and headers, the void forming nearly one third of the wall and being filled with rubble, that occupies the space with the projections of the stones forming the faces. This is a procedure familiar to the Roman constructor as that of this filling with small materials;

the Greek constructor did not make frequent use of it.

The principle is the same in the retaining walls; the stretchers alternate with long headers extending into the earth whose weight is supported by this masonry. All the difference is, that to better resist that stress, the wall is often flanked by buttresses, that make a more or less marked projection from the face of the wall. This is observed in the substructures of the terrace that the Pisistratides commenced to build at Athens to support the temple of Zeus Olympios.

The walls that limit and enclose chambers, those of the cellas, porticos and buildings of all sorts are much thinner. Only exceptionally in very large edifices does their thickness attain about 6.5 ft.; ordinarily it is scarcely 3.3 ft. The rule followed is that one never sees in the same course some stones extending through the wall and others stopping at the middle of its thickness; all the stones composing a course extend from one face to the other (Fig. 158), or indeed none of them extend through; a course of headers frequently alternates regularly with one composed of a double row of stretchers (Fig. 159). In a temple at Labranda in Asia, the constructor has left a space between the two parallel rows of stretchers, that are connected by headers (Fig. 160).

So that these walls are solid while remaining very thin, it is necessary for the materials composing them to be intimately connected, especially in the upper part of the structure; thus there in particular the absence of cement is compensated by means of metal cramps. It may be useful to specify by some numerical examples what we have said to the volume and form of the elements, that enter into masonry of regular courses. The stonecutter and mason very early contracted habits not entirely produced by the requirements of practice, but that suggested an arrangement of the materials in which taste found its place; these customs were retained without notable change until the last days of classical architecture. In masonry like the substructures of the Olympeion at Athens, that are concealed underground, they used great freedom; there in the same course are stretchers only 4.59 ft. long beside others that attain or exceed 9.84

ft.;[1] the height of the courses is further very unequal. We find that irregularity again in the foundations of the Barthenon. It is otherwise in the walls of the cella, whose masonry is always visible with its joints and contributes to the effect of the whole. There the courses are sensibly of the same height, and in each of these the height of the stretchers as 1 : 2.4. The ratio is verified according to the dimensions taken from a certain number of monuments and was nearly fixed.[2] That constancy is further not alone in the proportions; one again finds it in the dimensions of the blocks, that vary within quite narrow limits. Those blocks are generally from 4.10 to 5.25 ft. long by 1.64 to 1.97 ft high. These are not what one might term great materials. Those stones of moderate dimensions are effective, not by their mass, but by the treatment given by the workmen. One could say with the poet:- "the work is superior to material."

Note 1.p.337. Durm. Handbuch, Fig. 44).

Note 2.p.337. The same. p. 77.

3. Openings, Doors and Windows.

To arrange doors and windows in the walls, whose masonry we have just described, the Greeks employed two systems. In both the opening was closed at top by a horizontal lintel or platband; but this lintel was not always supported in the same manner over the space that it covered. Here it rested on two ascending pieces, actual stone posts, that were independent of the wall in which was pierced the opening; (Fig. 161); there it was borne by the courses of the wall itself, into which it was engaged by its ends (Pl. XI, all the doorways represented excepting two). We shall cite here only as a memory the third arrangement, that is merely a variant of the first, that which is only found exceptionally. This is the case where the verticals forming the jambs are intersected at the middle by one of the courses of the wall, that extends to the opening (Pl. XI, Alea, Assos, 3). Where this arrangement has been adopted, thes has doubtless been that men desired to dispense with erecting monoliths of great length.

There are very ancient examples of the two systems of a decided character. Thus in the treasury of Atreus at Mycenae, the doorway of the interior openu in the solid wall without

inserted jamb stones.[1] There are even certain edifices in which appear both types of openings. It is thus in the temple of Mt. Ocha, where the doorway has its proper enclosure, while the masonry is interrupted to give the windows seen at the side. In the facade of the market of Aegae in Eolia (Fig. 162) the windows also belong to two different types (Fig. 163). Yet it is certain that the system is that dating from the highest antiquity;[1] in the primitive structures b built of tamped earth, of almost rough blocks or small stones connected by mud, it is the sole means of obtainiug clearly limited openings with a firm and durable contour.[2]

Note 1.p.338. We term plates all those pages on which we have collected and systematically grouped the elements of construction or of the description of edifices. Although p printed with the type and inserted in the text, they have the same character as our large plates. We indicate for each plate the documents from which we have borrowed the figures comprised in that plate.

Plate XI. Elaeos (in Etolia); Lübke, Essai sur l'histoire de l'Art, Vol. I, Fig. 104; -- Assos, 1; Texier, Description etc., Pl. X bis. -- Thoricos, the atlas of the French edition of Archaeologie de l'Art, Pl. I, Fig. 14. -- Messene, 1; Expedition de Moree, Pl. 37. -- Oeniades, 1; Heuzey, L'Olympe et l'Acarnanie, Pl. XV,H. -- Phigalia, Guhl & Köner, La vie antique, Fig. 74. -- Paleo-Mani (Acarnania); Heyzey, Pl. 13. -- Oeniades, 2; Heuzey, Pl. XV,G. -- Orchomenos; Guhl & Köner, Fig. 77. -- Alea (Arcadia); Ramee, Historie generale d'Architecture, Vol. I, Fig. 171. -- Messene, 2; Expedition de Moree, Pls. 43, 45. -- Assos, 2; Texier, Description, Pl. 11, and Clarke, Investigations at Assos, Pl. 27. -- Assos, 3; Texier, Description, Pl. 111.

Note 1.p.339. Histoire de l'Art. Vol. Vi. pl. 6. It is the same at the treasury of Minyas. The same, Fig. 190.

Note 2.p.339. The same, Fig. 296.

Wood ordinarily furnished the jambs and lintels. Yet men thenceforth thought best to substitute stone for that use, at least in the ramparts of citadels, if not in private houses; at the Gate of Lions, four powerful blocks of limestone, cut in a stone harder than that forming the adjacent wall, form the enclosure of the opening.[3]

Note 3.p.339. Histoire de l'Art. Vol. VI. p. 188, 505.

Thus from that epoch, when the architect had to make openings in his wall, he could choose between two different methods according to his convenience. He retained this freedom the two types of doorways remained in use concurrently. One need not feel any surprise. When the masonry had attained that perfection and regularity, which characterizes the beautiful Greek masonry, why did they also frequently take t the trouble to give the doorway separate jambs, actual supports inserted in the wall? Did they desire to provide there an enclosure, which should outline the contour, nothing would be easier than to provide this by means of a moulding modeled sunken or in relief on the external face of the courses extendind to the void of the opening. That is what had already been done at the treasury of Atreus, where had been executed thus a casing enclosing the principal doorway. If they did not always adhere to such a simple method, this is because that they remermered the doorways formerly constructed, where that insertion was imposed by the nature of the materials, the jambs being of wood or of stone. For city gates, men are generally contented with the opening that c creates a void arranged in the mass of the masonry. Yet in the enclosures are some rare examples of gateways with jambs and lintel separate from the masonry. (Pl. XI, Alea, Messene 2). The other system, that inspired by the primitive type, was rather reserved for the doorways of temples, houses and other edifices of the same kind. This type is still more f faithfully preserved in the treatment of the windows, as one can judge from those pierced in the facade of the market of Aegae and in the walls of the tower of Andros, that is attributed to the 4 th century (Figs. 162, 163). No projection from the wall. The jambs are monoliths; the lintel extends into the courses and beyond the jambs. There is further a lower slab, doubtless a sill, and over the lintel is a covering slab intended to stop the drips from rain, both projecting slightly from the face of the wall.

Note 1.p.340. Histoire de l'Art. Vol. VI. Fig. 194.

Judging of them by the paintings on Greek vases, these o openings were enclosed between four pieces of stone or of wood, and were in common use on public or frivate edifices.

They are found represented, sometimes single and sometimes coupled, in more than one of those paintings (Figs. 164,165). In regard to this, it has been stated that only the power of old habits decided the Greeks to employ such singular construction, so out of harmony with the requirements of a normal construction. With that arrangement the jambs and lintel of stone are exposed to fracture, in case of a settlement of the courses.[1]

Note 1.p.343. Ch. Chipiez in Saglio & Daremberg's Dictionnaire. Art. Fenestra.

The masonry termed Hellenic by its horizontal beds and vertical joints lent itself best to the creation of openings made in a solid wall, without the insertion of any supporting member. Openings of that kind were also established in polygonal masonry, in that where the precision of the joints attests the mastery of the workmen; it sufficed to modify the stonecutting accordingly at the edge of the opening. It is then easy to cite more than one example. (Pl. XI, Oeniades, 2; Orchomene, Phigaleia).

In whatever masonry they are made, these openings are ordinarily closed at their upper part by a horizontal lintel. The rule is still not absolute. In Cyclopean construction, the opening ends in a triangle or pointed arch by the junction of corbelled blocks;[1] by a procedure of the same kind but with more ingenious stonecutting were executed the Mycenean domes. The use of the same method will continue to give openings, that close in various ways (Pl. XI). At Elaios is a triangular space formed by the courses of the wall; at Alea and at Messene (1) is produced the triangular top, here by two inclined and abutting lintels that connect with the jambs, there by the approaching of the courses. At Thorikos an opening with a pointed arch is formed by the courses of the wall. At Assos (1) the opening ends in a pointed arch by corbelling the courses. At Oeniades (1) the round arch is cut in two course stones, that touch at a vertical joint; no lintel. At Paleo-Mani, the two stones in which is cut the semicircle are separated by a narrow space covered by a great block that performs the function of a lintel. At Phigaleia a rectangular opening is surmounted by a lintel and ends in successive corbellings. At Oeniades (2) is a

trapezoidal opening surmounted by the lintel. At Orchomenos the lintel is of triangular form. At Assos (2) the opening terminates with cut-off angles. At Messene (2) beneath the lintel the jambs are attached to the wall and are in two p pieces. In a gate at Assos (3) the lintel rests on two courses at each side.

Note 1.p.344. Histoire de l'Art. Vol. VI. Figs. 195, 196.

Finally, over the gates of cities are found true arches with voussoirs, at least in western Greece, where one was much nearer peoples, who like the Etruscans had early made constant use of the arch (Fig. 166). Even skew arches are there.[2] The Greeks likewise could see the arch both in western Asia and in Egypt, and it is perhaps by the influence of those oriental models, that one can explain the use made of it in the walls of Cnidos. The Greeks were then early acquainted with the principle of the arch; if they made no m more use of it, this is because the materials at their disposal, very resistant limestone tufas and beautiful crystalline rocks, permitted them to cover the openings in a simpler and more rapid manner, than by the aid of voussoirs. In the simplest and noblest of their edifices are no other elements than lintels supported by the walls and columns; that is what has impressed on their architecture its original c character, and what has given to its monuments an exceptional stability.

Note 2.p.344. Heuzey. L'Olympe et l'Acarnanie. P. 150,Pl.1

What then conforms most to the genius of this architecture is the opening with all parts limited by straight lines, t that where the lintel is parallel to the sill. The opening of the doorway there forms in the vertical plane, sometimes a rectangle, sometimes a trapezoid. Of the two, the trapezoid is the more archaic form, which accords with the explanation that we have given to it, when we sought its origin in the procedures of the oldest constructors.[1] If they continued in even the 5 th century and still later to frequently give to the jambs that inclination more or less marked, particularly in temples and tombs, that is again by the effect of a very ancient custom. The eye is accustomed to that arrangement; to find it again, it experiences the kind of pleasure, that it feels in fixing itself on known forms and

familiar faces; perhaps one may say that it guides and leads the eye better to the higher parts of the edifice.

Note 1.p.345. Histoire de l'Art. Vol. VI. p. 505-507; figs. 191, 192, 193.

4. The Column, Proportions and Decoration.

We shall not speak here of the column nor of the proportions as we have done in the other parts of this history, in treating the general characteristics of architecture. It is easy to see why we have thought it necessary to modify thus the plan that we have followed until this moment. In the s supports of the mouldings, proportions and profiles vary, according as these members belong to the Doric or Ionic orders. One cannot consider these elements in an abstract fashion, by detaching them from the entireties whose character is difined by them. We shall then limit ourselves here to recall that the column does not alone figure in those e entireties. With its base, shaft and capital, it can form by itself alone an entirety, that suffices for itself and is an independent organism. In this manner the Greeks have frequently employed it as an isolated monument, as the support of a tripod or a statue; but the part that it plays in that way is only secondary. In Doric and Ionic temples its forms are especially developed and they have finally determined themselves.

We shall say as much of the decoration; as a mathematician would say, it is likewise a function of the order. According to the mode in which the edifice arises and of which it is the ornament, it changes nature and appearance; it has no real existence except by and in that; there is then no opportunity to separate them. When we shall describe the Doric temple, we will pass in review the motives, that the architect employs to accent the lines and clothe its members; we will do as much for the Ionic temple. With any other process of analysis, one would be exposed to lose sight of the unity of the work, that the artist has created.

Chapter III. Religious Architecture.

The Doric Style.

1. Importance of the Temple and Names of the Orders.

From the 7 th century in the history of the temple, to t the construction and decoration of which all the arts contributed, is summarized the history of Greek architecture. Then by the aid of the temple we shall study the two systems of proportions, the two modes or two orders, as it is said, between which are divided the preferences of the architect from that epoch until the last days of antiquity; they are known under the names of the Doric and the Ionic orders. As for the Corinthian order, it can be regarded as a simple variant of the Ionic order. Vitruvius is the most ancient author in which one finds explained the theory of the three orders;[1] but the names that he applies to each of those modes date much farther back. From the 5 th century they entered into current usage, at least for the two principal orders. Euripides having to mention the triglyphs, calls them Doric.[2] When were these terms adopted and how are then justified? Vitruvius does not tell us that, as at least the indications that he gives on that subject are very vague. The Greek architects , whose theory he knew and summarized more or less accurately, seem to be especially interested in describing the edifices that they had constructed; but they do not appear much concerned with the history of these types and the question of origin. All that Vitruvius finds to say on that subject is, that the first temple in which the forms of the Doric architecture made their appearance was the Heraion of Argos; Doros built it after having conquered the Peloponessus. As for the Ionic order, the Ionians invented it when they had to erect the temple of Artemis in the city of Ephesus; in that edifice were shown for the first time the profiles and proportions that form the originality of that system. The Corinthian order was so named because the oldest monument in which was placed the capital that characterized it, was erected at Corinth by Callimachos. All know the anecdote that Vitruvius relates concerning this.

Note 1.p.347. Vitruvius. IV, 1.

Note 2.p.347. Euripides. Orestes. Verse 1372.

We do not occupy ourselves here with the Corinthian order,

which was developed only in the course of the 5 th century; but the problem has more interest for the other two orders, whose origins are confused with even those of Greek architecture. Is it true that the Heraion of Argos, erected by t the Dorians established in that city, was the first Doric temple that Greece consecrated to her gods? We cannot say. Of the edifice destroyed by fire in 484, there remains only the terrace that supported it. Further, there being given the traits assigned by tradition to the Dorians, it does not seem probable that those rude and bold soldiers, soon after having ravaged anf subverted Greece, would have played the chief part in the creation of a new form of art, a form of which certain peculiarities are explained by methods of construction peculiar to the Mycenaean age.[1] Yet one cannot allow himself to comprehend how was introduced into the language the name that has prevailed. Masters of Argolis, Laconia and Messenia, the Dorians exercised an uncontested supremacy over the entire Peloponnessus. Now in that country arose the first temples built according to this mode, t those regarded as the oldest examples. Was it not natural, that without asking to what tribe belonged the architects to whom was due that advance, men attached to this type the name of the Dorians, the Peloponessus having become almost a Dorian land?

Note 1.p.348. Histoire de l'Art. Vol. V. Chap. VIII.

As for the ionic style, it had its roots in Asia; as we have already stated, certain arrangements peculiar to it might be suggested to the Greeks of Asia Minor by oriental models.[2] In any case Ionia was the cradle of this style; t there was it constituted, then to diffuse itself throughout all Greece; in that region it has always been more in favor than the Doric style. The term Ionic order is then more justified than the corresponding term, from the point of view of history; it is more according to the reality.

Note 2.p.348. Histoire de l'Art. Vol. II, p. 218-222; III, p. 694-895.

Otherwise these observations can have only an interest of curiosity. Each of the terms in question designates a clearly defined system; we shall then employ them, as men did not cease to do in antiquity, without troublinm ourselves conc-

concerning their origin.

It is proper to commence this study with the Doric order. not that the Ionic order may not be in a certain sense as ancient as its rival; one can seek its rudiments as far in the past; but it is still the Doric that was first constituted and that presented the richest development in the 7 th and 6 th centuries. Before the Ionic it had created forms and had drawn up a system of proportions that it will never abandon, which from the beginning is nearly that to which it will adhere in those of its types regarded as noblest, as even the perfection of the species. Also on the Doric mode depends the most ancient temples built in the plain of Olympia and in the most important cities of Greece proper, of European Greece at Athens, Argos and Corinth. Finally, as we have already indicated, and if one may so speak, this style has its roots in the most ancient methods of construction, that were applied by the ancestors of the Greeks of history. Certain elements that compose it and make its originality have already appeared to us in Mycenaean architecture

2. The Origins of the Order and of the Doric Temple.

To remain faithful to the method that we have followed, we shall also here carry ourselves back to the origins; we shall ask these to aid us in determining the characters that distinguish each of the two great orders. The genesis of the forms explains their development.

To seek where and how was born the Doric temple, will be to go back as far as possible in the history of the stone temple. In the Doric style were constructed the most ancient religious edifices that merit the name of temples, at least the most ancient of which some remains have been preserved.

Men have pretended to recognize the prehistoric model of the Doric temple in the hut made of beams and planks. Doubtless it is not impossible, that in distant times buildings in which wood dominated were devoted to religion; but in any case in whatever way it is represented, the hut gives no reason for the very particular arrangements that characterize the Doric temple. Further, as it is constructed entirely of wood, the cabin does not seem to have ever existed f for the needs of the cause, at least on the soil of Greece.

the most rustic buildings of which traces have been found in this country had walls of earth with ties of wood. The champions of that hypothesis then start from an abstraction, from an imaginary type. We shall not stop here to discuss this theory and to show its improbability. What we will set forth has the advantage of not giving the same opportunity for free conjecture, and of finding its solid foundaition on recent discoveries, with which one reaches a past much earlier than the time at which was constituted the Doric system.

Our starting point is a type of edifice that we have already found everywhere on our way, at Troy and in Beotia as at Tiryns and at Mycenae. This the megaron, the great hall that formed the open and public part of the houses of Achaian princes and nobles. In attempting to restore the architecture of that period, we have given the plan of those buildings which appeared to have most importance.[1] Here is t that of an ordinary megaron of small dimensions; it is one of the numerous edifices of that kind, whose traces were found by Dörpfeld in his latest excavations at Hissarlik. (Fig. 167). Its arrangement is most simple. Nothing more than a great room preceded by a vestibule or prodomos comfrised between the projecting ends of the two walls forming the larger sides of the rectangle. Those walls and those of the ends are of stone. Blocks of quite large size form the foundations. Above they built these of crude bricks or small materials.

Note 1.p.350. Histoire de l"Art. Vol. VI, Figs. 48, 50; pl. II, M; Figs. 83, 116.

This plan is that of certain little grecian structures, of those that are the prototypes of what are termed temples in antis; but the Doric temple, where it possesses its full development, presents an arrangement quite otherwise complicated. This arrangement, which is that of the most celebrated monuments of Grecian architecture, how shall it be connected with the megaron, and by what way shall it be derived just as the adult and complete plant starts from the germ, that already lontains it, concealed in the mystery of its cells, the organs at the same time most complex and most 1 delicate?

There is only the appearance of a difficulty. Created for the man in view of the princely life, the type of the megaron is suited without effort to receive a more elevated destination. It was the noblest and most beautiful type of edifice known; it appeared quite naturally designed to furnish the gods with habitations, in which the piety of their worshippers invited them to establish themselves. This was the time when by the continuous and bold effort of its thought, the Grecian mind gradually detached itself from the primitive animinism, in which it completed the designing of the figures of those Olympian deities, who were grouped around Zeus and already had in the epic such clearly defined traits and attributes. For these divine beings, who were supposed to divide the government of the world, were required dwellings more ample and more beautiful than those of cen of the highest rank, of the kings themselves. To appropriate the megaron to its new function, men were not content to enlarge it; it might be longer and wider than in the palace without gaining much majesty. Then it was reproduced in its more developed form, such as it was at Tiryns, for example, with columns between the antes,[1] and it was multiplied by itself, if one can so speak, by placing two megarons back to back. There was necessary a suggestion of the rear walls, but each of the edofices so attached, retained its prodomos, that became a pronaos. Whatever its dimensions, the edifice thus took an amplitude of appearance to which could not pretend the former palace, even where it was most vast. There was not in the temple a side that was sacrificed, as the case in the magaron. If one facade, ordinarily that turned toward the East, was distinguished from the other in that the wall of the pronaos was pierced by a doorway, that gave access to the interior of the sanctuary, the two facades were symmetrical and similar, with that exception. At a distance the eye of the spectator made no difference between them.

Note 1.p.351. Histoire de l'Art. Vol. VI, Fig. 83.

The innovation had its importance; still it did not seem to render the building worthy of the august guest, who must make it his house. Already the doubling of the vestibule gave more mass and effect to the whole; but the long walls forming the longer sides of the rectangle still remained

cold and bare. To correct this defect, some one conceived the enclosing of the entire structure by a row of columns. This ornamentation with the multiple repetition of its supports separated by equal intervals, gave to the edifice m more amplitude and effect; It seemed to make this lighter. It doubtless suggested to the Greeks the idea of calling t that external colonnade a wing, from which the names of the temples, peripteral, dipteral, pseudo-peripteral, that designate the different arrangements that the inventive minds of the architects in time derived from this principle. These columns contribute to support a ceiling, whose elements rest at one end on the entablature borne by their capitals, and at the other on the wall that they adjoin. Thus is constructed entirely around the temple a covered promenade or portico. It has been asked whether the sight and the knowledge of the monuments of Egypt did not have some part in t the creation of the Doric temple; perhaps the question does not admit of a sure solution; in any case we shall have occasion to return to it.

On nearly all Grecian temples, six columns are presented at each end by the external colonnade. That arrangement does not result from the caprice of the architect; even the principle of the plan imposes it. Two of the columns of the portico correspond to the two columns erected between the antes; two others are opposite the ends of the walls of the pronaos; finally there are two that terminate the rows of columns f forming the lateral porticos (Fig. 168). The temple is then born a hexastyle, if one may so speak; and it will so remain always. We have to cite but very few exceptions to that rule, for example the temple T of Selinonte and the Parthenon, w which are octastyle. It there concerns edifices that leave the common system and to which men desired to give a very particular character of grandeur and of luxury.

If one thought of erecting thus the column outside the t temple so as to decorate the sides of the edifice, this was not to suppress it where it already existed in the interior of the great hall, that represented the ancient megaron; there it furnished the extent of the great room, and it supplied useful points of support for the wooden beams, that had to bear a heavy terrace.[1] The arrangement of the hypos-

hypostyle was then retained; but the architect continued to develop the plan of the edifice, brought these columns nearer the wall and increased their number, and thus he divided the interior into three aisles of unequal width, two of which were narrower and formed porticos extending along the side walls. With this double vestibule and this double colonnade, external and internal, the type of the Grecian temple is created; it already presents traits that will define it in its most finished examples. The genius that produced it did not then proceed by a series of retouches and additions, as sometimes believed; it did not advance slowly from the simple to the complex. In this type the minds of the architects will further introduce only variations of secondary importance. We shall record them as they are produced; but they will not have the effect of altering the character of the whole, such as it presents itself in the most ancient monument in which history can study it, the Heraion of Olympia.

Note 1.p.353. Histoire de l'Art. Vol. Vi. Figs.83, 305, plate XII.

There are not ended the relations that we have to point out between the Mycenaean palace and the Hellenic temple. Enlarged and embellished, the megaron has become the house of the god, who will be represented there by his statue, when sculpture has emerged from its infancy; but the altar on which will be offered the sacrifices in honor of the divinity that inhabits the temple remains where it was formerly in the enclosure of the palace; it is placed outside and before the temple, as it formerly was before the residence of the hereditary chief, both king and priest.[2]

Note 2.p.353. Histoire de l'Art. Vol. Vi. Figs. 83, 305, plate XII.

This altar is placed between the facade of the temple and a building pierced by one or more doorways, that announces afar the sacred enclosure and opens it to visitors. This is what is called the propyleion or propylea. It would have seemed scarcely worthy of the majesty of the god for his house not to be preceded by an edifice, whose monumental character warned the passer, that once passing this threshold, he walked on consecrated ground. We have found these propylea in Egypt, Phoenicia and in Judea, where we have t

termed them pylons.[3] But it is perhaps unnecessary to return to oriental models in order to explain their presence in G Greece. The feeling that suggested the adoption of this idea is that of every country; it is of all time; when he constructed his palaces, it dictated to the Mycenaean architect an arrangement, that his successors of the historic age have repeaduded until in the Macedonian and Roman ages; the sole difference is that by the use of the nobler forms of a wiser art, they have given to these buildings a more elegant and grander appearance. Sometimes, as at Egina, Eleusis, Sunion and Priene, these propylea only give access to a single temple (Figs. 169, 170, 171). Elsewhere, as on the Acropolis of Athens and at Olympia (Fig. 172), by traversing them one enters an enclosure in which are collected several temples. They may be single, as at Egina (Fig. 169) and Selinonte (SFig. 173), or double,as at Tiryns (Fig. 174), Delos and Eleusis (Fig. 170). Otherwise, in the less complicated arrangements as in those more so, the propyleion reduced its essential elements, consists of columns ranged in two rows in front, sometimes also of two longitudinal rows, and comprised between two great walls. This entirety is connected to the enclosing wall, and whatever variety is presented, one finds there always the type created by the constructors of the Achaian age. There is one of those close and undeniable resemblances, which attest the direct connect connection.

Note 3.p.353. Histoire de l'Art. Vol. I, p. 344-348; Pl. IV; Figs. 206, 207, 214, 218; Vol. III, pa 248, 266, Figs. 19, 199; Vol. IV, p. 281-286, pl. IV.

Then was made that transformation of the livil into a religious edifice, certain characteristic details having passed without notable change, from the original type to its brilliant derivative. Thus the prodomos of the primitive h house has become the pronaos of the temple. Under the simplest form, that affected by the Trojan house (Fig. 167), it had a simplicity that could lead to no development; but what served as a model for the classical architect and which furnished him with the facades of his temple is a wider prodomos of the royal edifice of the preceding age, that w where two columns stood between the two antes. The megaron of the Trojan house was covered by beams extending transv-

transversely from one wall to the other for the entire depth of the building. We shall show that covering in perspective (Fig. 175) and in plan (Fig. 176); we shall call A the length of the beams. Assume a hall of much greater dimensions, analogous to those of the palaces of Tiryns and Mycenae; the width of this hall will be conventionally twice that in the preceding type. How did they succeed in covering that space? Nothing more simple. They take beams of equal length A, but placing them lengthwise, causing them either to rest on the wall separating the vestibule from the megaron, or on transverse girders of greater dimensions, placed at certain distances (Figs. 177, 178). No deflection is to be feared. Solidly built at the ends into the great walls, these girders found double points of support for their middle part either on the columns of the prodomos or on those of the interior of the vast hall (Fig. 179). This carpentry thus forms in the direction of the length of the interior a series of compartments, each of which consists of two girders, and by a series of beams more or less close. The appearance of the front varies according to whether one or the other arrangement was employed. In the first case, what one perceives from the exterior above the entrance opening was one side of the last beam, that nearest the exterior; in the second type the ends of the beams appeared above the architrave and were opposite the spectator.[1]

Note 1.p.357. Histoire de l'Art. Vol. VI, pls. XI, XII; Figs. 302, 303, 305, 307).

Wood appears to have furnished in the temple the material of the most ancient columns, those of both exterior and interior. The column of the Mycenaean constructors was of wood,[2] and one has the proof that the architects of the first Doric temples began by remaining faithful in that respect to the customs of their predecessors. Pausanias found those old columns of wood again at Olympia, where they were shown and preserved as curiosities, not only on the site of a vanished structure, that had been the house of Oenomaeos, it was said,[1] but also in the temple of Hera.[2] Yet there must have been an early difference. The column of the vestibule and of the interior of the Mycenaean palace was connected to an architrave fixed in the wall at its ends. In these

conditions, the column, not only without inconvenience but even with advantage, could take the form of the leg of a chair, of an inverted conical shaft.[3] In the temple the portico surrounded the cella on all sides, and a certain distance separated the supports from the walls of that cella; it resulted that meeting at the extremities of each face of the portico, the architraves formed there a projecting angle whose apex was turned to the exterior. Two architraves then rested at the same time in a right angle on the four corner columns. There had never been anything similar in the Mycenaean megaron. The use of the peripteral arrangement, i.e., of supports accompanying the four sides of the cella, then completely changed the conditions of the stability of the column. With that arrangement, one was necessarily led to erect the trunk of a tree just as it was in nature, so that the column was at least as thick at its base as at its tip, or it rested on the ground at its largest part, whether cylindrical or conical.

Note 2.p.357. Histoire de l'Art. Vol. VI, p. 282, 286.

Note 1.p.358. Pausanias. V, 20, 3.

Note 2.p.358. Pausanias. V, 16, 1.

Note 3.p.358. Histoire de l'Art. Vol. VI, p. 320-321.

We shall state now and for what reasons the constructor was brought to substitute stone for wood in the column, and also elsewhere; but before entering into details in describing the temple and the different parts composing it, it remains for us to indicate in that edifice a last peculiarity, which is explained by the origin that we have attributed to it. In the great rectangular hall that the Greeks called the naos and the Latins the cella, we have recognized the megaron of the Mycenaean palace. When the god came to replace the king there, there was added an external colonnade in honor of the new master of the house; but this only surrounded the principal building; it had not become solidary. That is shown in striking fashion by the actual state of the temple of Segeste (Fig. 180). In that temple the portico or the pteroma, as the Greeks called it, entirely exists, while nothing remains of the walls of the cella. There was then no effective connection of these two parts of the edifice; the fall of one did not imply the destruct-

destruction of the other. There is a peculiarity that does not fail to surprise at first sight, but which is explained when one studies with some care the arrangement of that portion of the structure; as it is easy to verify, the sole c connection of the cella of the portico was the series of slabs forming the ceiling of this portico. That is made apparent by the adjacent sketches, which represent the pronaos of the so-called temple of Poseidon (Fig. 181) and that of the temple of Bassae (Fig. 182). It is a little different in one of the most celebrated monuments of Athens, in the pronaos of the so-called temple of Theseus; but if in that edifice the entablature of the pronaos extends even into the portico, this is because the architect desired to place there a frieze with continuous sculptures, and consequently to enlarge the field that he left to the sculptor (Fig. 183)

Note 1.p.360. This arrangement is not reproduced on the rear facade, where the shorter Ionic frieze extends only f for the width of the cella.

There can be no question of establishing a comparison between the height of the columns of the portico and that of the columns of the internal order. The latter being doubled in height, the elements composing them are necessarily of less dimensions than the supports of the external colonnade; but taking the value that the modern constructor attaches to perfect symmetry, we should have been tempted to expect to find a relation fixed between the axes of the columns of the portico and those of the columns that divide the cella into three aisles. Now this relation does not exist. The a axes of the internal columns do not correspond to those of the external columns, and do not fall at the middle of the interval between them. There is scarcely an exception but for the temple of Hera at Olympia; there the correspondence of the two series of axes is sensible on the sides (Pl. XII) In the same order of ideas, one will note that frequently the antes terminating the facade of the naos do not correspond in plan to the columns of the portico; thus on the temple of Zeus at Olympia that ante appears in the space of an intercolumniation (Fig. 184). It is the same on the temple R at Selinonte (Pl. 38).

Further see what shows better still how loose is the mat-

material relation that unites the cella and the colonnade surrounding it, the naos and the pteroma. There are temples, like the temple of Theseus and the temple of Zeus at Olympia where the architrave of the cell and that of the portico are found at nealr the same height above ground. In the temple of Poseidon at Paestum that correspondence no longer exists; the entablature of the naos is at a higher level (Fig. 185). The contrary is observed in the temple of Bassae. There it is the architrave of the naos that extends at a higher level (Fig. 186). The difference is still more marked in the same sense at Nemea (Fig. 187). If the naos and the portico are thus independent of each other, this is because the first of the two, which is nothing else than the ancient megaron, preexists in the second. The latter even when most developed always retains the character of a complement, of a brilliant ornament, and of a vestment that although cut to the m measure of the body, can be detached from it. Yet the edifice has its unity, if not for the critic who takes it apart in pieces, still at least for the uninformed spectator, whose eye comprises it in a general and rapid view. That unitw is obtained in great part by means of the roof, that like a platform covers both the two parts constitutinm the temple and gives to that entirety the appearance of a single edifice, of an indivisible whole. It is also in the character of the execution. Everywhere in the portico as in the cella, the supports, mouldings and ornaments bear the mark of the same style and the same taste.

3. Transition from Wood to Stone. Temple of Hera.

Before beginning the analytical study of the stone temple it is proper to call attention to an edifice unique in its kind, the temple of Hera at Olympia. The heraion was the m most ancient sanctuary contained within the sacred enclosure to which was given the name of Altis. A very particular veneration surrounded it as the first cradle of the worship of Hera and of Zeus, as the first monument in the shadow of w which were celebrated those periodical solemnities, that ended in attracting to the banks of the Alpheus even the Greeks established at the most distant part of the Euxine or on the coasts of Gaul, of Italy and of Africa. More vast and sumptuous edifices were erected at length at the foot of

Cronion; but the ancient structure preceding them by several centuries had been maintained with care. Men had not failed to renew its elements as decay attacked them; but men endeavored to preserve as much as possible its primitive appearance. In the rear of the temple stood two colossal statues of Hera and of Zeus, a fragment of which, the head of Hera, was found in the course of the excavations; the place occupied by those images is still marked on the ground by the foundations of the padestals. Other works, especially those of archaic art, were grouped around those figures. Thus the opisthodome contained the celebrated chest of Cypselus, whose rich ornamentation offered to the spectator the combination of themes, that were most familiar to the artist of the 6 th century. Later, in the museum that each generation held it an honor to enrich, a more advanced art had brought some of its masterpieces; there was unearthed the Hermes modeled even by the chisel of Praxiteles.[1]

Note 1.p.362. We merely summarize in this Chapter the description so minutely exact that Dörpfeld has given of this monument. (Olympia. Die Baudenkmäler. Vol. I. 1892. Plates 18-23; text, p. 27-38). The adjacent Figures are borrowed from the pales of that work.

Not without vivid regret does one read in Pausanias the long list of all those lost monuments; but had we found them again, the capital discovery would no less have remained that of the temple itself. The most important of the results produced by the German excavations executed from 1875 to 1881 at an expense of more than a million francs ($200,000)is still perhaps the uncovering of the remains of this old edifice, the revelation of its so peculiar plan, and of the methods of construction that had been applied to it. We esteem at its just value the marvellous statue, that an unhoped stroke of fortune restored to light, and of which only a very imperfect idea is given by the dull coldness of the plaster; but other marbles had already allowed us to divine the genius of the master, while in all researches undertaken on the soil of Greece, nothing had come to us to indicate what the Greek temple might be in the 8 th centurw, and of what materials it was built and the arrangements that it presented. One cannot doubt that the Heraion already existed from the

time of the first olympiads, with what there was asserted in the traits that characterized it, traits that were scarcely modified by later restorations. Perhaps it even dates earlier yet; at least so the architect is inclined to think, who has best studied all that remains of the monuments of the Mycenaean age and of the archaic age, M. Dörpfeld.[1] The adjacent elevations and sections give us an idea of the condition in which that edifice was found. (Figs. 188, 189, 190 191). We have already shown the plan (Pl. XIII).

Note 1.p.365. Dörpfeld would be tempted to admit a basis of truth in the tradition mentioned by Pausanias, according to which the temple was built 8 years after Oxytes obtained possession of Elis, i.e., according to the chronology generally accepted, about the beginning of the 11 th century. ((Olympia. Textband II, p. 35,36).

Without entering into details, we shall limit ourselves to indicating those characteristics of the primary construction not effaced by later restorations, and that besides the text of Pausanias, are verified by the careful examination of the ruins of the temple.[2]

Note 2.p.365. Assuming the point of view on which we place ourselves here to study the temple of Hera, we do not restore certain peculiarities, that have their importance, as for example, those little transverse walls that connect to the walls of the naos eight of the shafts of the internal colonnade, and which those constitute along the latter walls on each side, as it were, four rectangular chapels and a little niche. We shall have occasion to return to this temple.

These characteristics reduce to three principal ones.

1. The columns of wood that formed the pteroma.

2. The crude brick walls of the cella, that rest on a s substructure of cut stone.

3. The wooden timbers or planks covering the jambs of the doorway and the antes of the pronaos.

It is self-evident that there has been found not the least fragment of a wooden column; but if before describing the monuments of sculpture contained in that museum, Pausanias had only said a few words about the temple itself and its architecture, yet he inserted a very curious statement. He writes,"one of the columns of the opisthodome is of oak

wood." The opisthodome is here the rear pronaos.

One could already deduce from this text that the column mentioned by Pausanias was the last survivor of numerous smiliar columns; does this represent a temple in which the colonnade was equally divided among those of stone and of wood? The excavations have completed the demonstration; they have supplied the proof of most and at least all the stone columns. From observations to which these remains have given rise, it has clearly resulted that the columns found are not contemporary with each other.[1] They are neither alike in diameter, in the number of flutes, nor in the capital. In the profiles of that last member are the most marked differences. There are capitals , some of which appear to date from the 6 th, others from the 5 th or the 4 th centuries; and some from the Roman epoch. There is only one way to explain such evident variations. In their attachment to the past, the piety of the Eleans endeavored to preserve as long as they stood on their bases the ancient wooden columns. At need they employed columns, as had been done for the pillar of the house of Oenomaos. It was only when a shaft of oak by its state of decay threatened to fall, that it was decided to replace it by a shaft of stone. A century after the visit of Pausanias, one would probably have no longer found that last evidence of the ancient construction, where the traveler had seen it; time must have brought it to an end.

Note 1.p.366. Dörpfeld. Olympia. Vol. II. pl. 20, 21; textband II, p. 28-30.

Except the difference in entasis, this column is that which we have everywhere restored at Tiryns and Mycenae, according to the traces left on the ground, under the form of a plinth or disk of stone, that served as a support for the wooden shaft.[2] We shall state why one finds at the Heraion no vestige of these rudimentary bases, that here in the first state of the temple must have existed beneath the oaken columns.

Note 2.p.366. Histoire de l'Art. Vol. Vi. p. 518.

The construction of the cella presents peculiarities no less curious. There remains only a foundation of dressed s stone. Now the nature of the rubbish removed from the interior of the temple and its surroundings confirms a hypothe-

hypothesis at first suggested by the uniform height everywhere shown by this wall and by the absence of all marks of fastenings on the top bed of the upper course, the entire remainder of the wall was of crude bricks, as in certain edifices of the preceding age.[1] Nor has any stone been found whose cutting indicated that it formed part of the entablature. This was then entirely of carpentry as at Mycenae.[2] That is what must otherwise be expected. How could wooden columns support a stone entablature?

Note 1.p.368. Dörpfeld. Olympia. Textband II, p. 31.

Note 2.p.368. The same, p. 30.

Even after the gable roof was substituted for the ter ,
the edifice must have had but a moderate height. The slope of the pediment is given by the antefixa remaining; and by using that indication and reducing to a base of equal length the temple of Hera and that of Zeus at Olympia, the adjacent diagram is obtained, from which it results that the Heraion was lower and of more squat proportions than will later be the hexastyle temple (Fig. 192).

Let us return to the foundations. If the eye of the passer merely glances at it, the observer finds there matter for reflection. Seen from within the cella, this tufa wall consists of four regular courses, one of which is almost buried in the soil (Fig. 193). Seen from outside, it presents an entirely different appearance. The external face is made of great stone slabs set side by side, each of which had the height of the four courses for which it served as a facing. (Fig. 195).

This is truly a singular method of construction. One does not understand at the first moment why the masonry does not frankly appear on the exterior as in the interior. Thus set on edge, the slabs do not bond with the wall but risk being detached from it. If the workmen adopted this method, it is because in the houses and palaces of prehistoric times their predecessors must have employed these slabs of stone to protect the base of the wall, of a wall made of clay bricks or of rubble connected by a mortar of mud.[1]

Note 1.p.369. Histoire de l'Art. Vol. VI. p. 729.

It is the same for the antes and the jambs of the doorway of the naos. The antes are of stone; but on their front and

internal surfaces one notices grooves in which were fastened the planks and the blocks on which were fixed by nails the planks concealing the mass of tufa. In the adjacent sketch to illustrate how this facing was arranged, we have restored some of those **planks** (Fig. 194). For what did they serve? The stone is harder than the wood. If it appeared in that place, this is because it occupied this in the earlier buildings, where this screen protected the projecting ends of walls of crude bricks.[2] Without that defense on that sort of projection beaten by rain on three sides and exposed to all shocks, the masonry would not have delayed to disintegrate. Besides, here this facing was useless by reason of t the peripteral arrangement; the antes were sheltered by the portico.

Note 2.p.369. Histoire de l'Art. Vol. VI. p. 500-502.

These grooves arranged in the tufa are found on the blocks forming the sill and casing of the doorway of the naos; they could only serve to receive a horizontal piece by means of which was effected the connection of the stone and the wood. (Figs. 194, 195, 196). The stone threshold bears the marks of nails;[1] one recalls the sills of oak or ash mentioned in Homer.

Note 1.p.370. Histoire de l'Art. Vol. VI. p. 502,503,512.

Was the wooden covering at the antes and the doorway ever covered by a metal? Did sheets of bronze serve to render t that trimming both more resistant and more ornamental? One does not know and it matters little. What forms the interest of the peculiarties mentioned is the conclusion that these authorize; when the hexastyle temple was created, the constructor still remained faithful to the methods of the Mycenean age, and on the other hand, if he applied them, this was not because they were justified as before by practical needs. He obeyed one of those habits that survive the circumstances and requirements that produced them; he docilely followed one of the traditions transmitted in the trades as a heritage from generation to generation.

Then the Heraion of Olympia is what may be termed a transitional monument. By it we divine how the architect passed from the megaron of the Achaian kings to the temple of stone; by studying it can one explain how certain arrangements, t

that characterize the buildings of the earlier peeiod, are preserved in that edifice by the effect of routine.

4. Analytical Study of the Stone Temple. The Doric Temple. Stone enters into the construction of the Heraion for but a small part; the chief role there devolved on clay and wood. Now it is not with such materials that the architect could ensure the duration of the temple and thus render it worthy of the occupant for which it was intended. Such an architecture could only be a transition architecture; while it employed no other resources it never succeeded in expressing by the entirety of the forms that it essayed to create, the i idea whose sensible expression it sought, that of divine m majesty and permanence. Chiefly built of rubble, crude bricks and wood, the temples had but a limited and precarious existence. In spite of the plastering applied to restore it, the rain cut into the crude bricks; it rotted the wood, that the extreme heat cracked in a different season. In such conditions, it was also difficult to attain the beauty of lines as in the solidity of the work. Neither the rubble nor the tamped earth lent themselves well to the execution of the mouldings. Those could appear in the wood beneath the chisel or the gouge, but they always retained their dryness there; their profiles were soon injured by the dampness. Only the stone with its close grain could give the contours of the forms an amplitude that satisfied the eye, and could preserve for it indefinitely the character of nobility impressed on it by the tool. That had already been understood by the Mycenaean artist. If in the palace, a temporary edifice, he rarely employed anything but wood, but in the domed tombs that became eternal dwellings, he used stone and chiseled on it a rich decoration. He could not delay to seize the a-advantages of stone as soon as, to satisfy some social need, he commenced again to build important edifices that should cover a great area of ground. Over those interiors it was necessary to extend wide roofs; did not stone furnish supports better suited than trunks of trees, never to bend under those heavy loads? These simple reflections must suffice to suggest to the constructor the idea od modifying his habits; but it is possible that the example of Egypt may have contributed to push him into the new path. The most ancient tem-

temples with stone columns and entablatures known to us do not date beyond the 7 th century; most are of the 6 th. That is the time when the Greeks began to frequent Egypt; they establish agancies in the Delta; as merchants, mercenaries and inquirers, they ascend the valley of the Nile; they contemplate the enormous pylons, the long series of porticos, the lofty hypostyle halls. The admiration that they experience at that sight does not make them faithless to their n national traditions' but before those grand monuments, all built of beautiful limestone and granite, perhaps sooner a and more vividly than they would have done without this view of the marvels of Egypt, they felt the special virtues of the stone, how it alone could give to the entirety that air of powerful solidity, that seemed to them to promise a duration without end, and it ensured to all profiles that firmness of line without which there are no harmonious proportions and expressive beauty.

Such were the reasons that caused the rapid abandonment of the former methods, the architect thus foond himself placed in conditions, that differed greatly from those in which his activity had been exerted until then; the change in material implied a change of forms. As these forms appeared in the oldest Doric temples, and as they were maintained to the end with very slight variations, are explained by the transition from wood to stone, by the properties of stone, and by its requirements and its merits.[1]

Note 1.p.372. See Ch. Chipiez. Histoire critique des ordres grecs. P. 239-240.

The use of cut stone allows the placing of the edifice on an ample and strong substructure, a part of which is in the ground and forms the doundations, while the rest is above it and forms the stylobate. ("On which rests the columns."). The stylobate is a mass of masonry interposed between the ground anf the foot of the walls as well as that of the colonnade. This mass, measured at its base, covers a surface whose dimensions exceed in all directions those of the area occupied by the structure of the temple. Thus it is limited in height by two horizontal planes of unequal extent, connected together by broad steps. The entirety of this base t then has the character of a truncated pyramid, but whose s

slopes are concealed beneath the projections of these steps. This substructure isolates and elevates the temple; it plays the part of a majestic pedestal that raises it above the heads of the multitude and points it out afar to the eyes.

We have stated elsewhere from what need originated the base of the Mycenaean column.[2] It was necessary that the lower end of the wooden shaft should never be wetted by the dampness of the ground; for this served the found stone disk found in place in the edifices of the Achaian age, wherever there were columns with the stylobate that need disappeared. Itself being placed on the thickness of the foundation, the stylobate suffices to protect from contact with the wet earth all the construction that it supports; thus it plays the part of a base common to all the supports. If henceforth the architect gives a base to his column, this will be for reasons of sentiment and of taste; no necessity of construction compels him.

Note 2.p.372. Histoire de l'Art. Vol. VI, p. 521.

The creators of the Doric architecture did not thus complicate the form of that support; besides they were not incited to this by models under their eyes. The Mycenaean base was never more than an insignificant plinth not exceeding a few inches above the ground; the capital alone of that column had any importance. The architect then neglected that thin slab, which had become useless to him; he has contented himself with taking the Mycenaean shaft, if one can so speak, inverting and replacing it. That had as a base its least diameter; its top was enlarged to present its largest area under the architrave. Thus is the inverse phenomenon produced when the column is cut in stone; it is then it is larger near the ground than where it meets the capital. Why this method was taken is easily understood. If one replaces wood by stone in the column, this is that it may be more suited to bear a heavier load; it is necessary that the form to be given to the shalf be calculated so as to make it as stable as possible. Now it is the conical form that ensures the most perfect stability to the pillar; as the eye divines and as statics demonstrates, the cone has a firmer bearing than the cylinder comparable to it. The first Doric column was then a truncated cone, cut off far from the vertex;

thus was given to it a short and squat height that increased the resistance (Fig. 197). On the column of the old temple at Corinth the ratio of the height to the greatest diameter of the shaft is nearly 4 to 1; the column hardly has more than 4 diameters.[2] That column is monolithic like the trunk of a tree that it succeeds. It is the same at Syracuse in the so called temple of Artemis, which itself is very ancient. (Pl. XIII).

Note 1.p.373. Histoire de l'Art. Vol. VI. p.51_-529.

Note 2.p.373. The exact proportion for the columns of the facades is 1:4.2, and for those of the long sides, 1:4.4. Dörpfeld. Der Temple in Korinth. Athen. Mitt. 1886.p.304).

Taking the rigidity of the stone of the form taken by the column, it was no longer necessary for it to have as much material beneath the capital as the wooden column; but on the other hand, it would not have sufficed for the column, that diminished in ascending, to have by means of the capital the diameter that it had its foot; it was necessary for this capital to have the form of a slab to receive on its entire breadth the under surface of the architrave; this was the role of the abacus. To connect that abacus to the shaft, more detached than before, one must enlarge the curve of the interposed moulding of this torus or cushion, the abacus, that we have already seen appear at the same place on the Mycenaean column. Thus is obtained a capital, that is composed of the same members as that of the primitive column, but expands more boldly and offers a firmer and nobler profile (Pl. XVIII).

If the wooden column could only bear a wooden architrave, the column of tufa called in the same fashion for a stone entablature. Long blocks of tufa, a true beam of stone, will henceforth fulfil the function of the architrave. (Fig. 198).

But in passing from the megaron to the principal temple, the architrave of epistyle has suffered a notable change in condition. In the vestibule of the megaron, if the architrave be supported at its middle on two columns (Fig. 177), both ends rest on the side walls, where it is engaged in the masonry (Fig. 179). It can no longer have these walls as s supports in the temple, where the portico is independent of the cella, and instead of extending only on the facade, it

runs around on the four sides of the building above the colonnade. Two architraves meet at each corner of the edifice, whose ends can rest only on the angle column (Fig. 199). They are not assembled like two timbers; they are only abutted at their ends; but they have the benefit of stonecutting, that allows the two concurrent architraves to be represented on the abacus by nearly equal areas. This cutting at the same time offers the advantage, by its reentrant and convex angles, of rendering the contact more perfect between the two adjacent cuts.

On the architrave was supported the frieze, the origin and function of which we have had occasion elsewhere to indicate. This in its entire extent on the four sides of the pteroma is ornamented by triglyphs, that separate rectangular panels termed metopes.

Note 1.p.377. Histoire de l'Art. Vol. VI, p.687-698, 711-714, 722-723.

The frieze was surmounted by the cornice, and had as purpose to support the roof and to cast the rainwater to a distance. There again the architect has made a work of art by adopting the forms of the primitive carpentry, that enclosed and sustained the earth roof; he gave to it a happy appearance by the proportion arranged between the different mouldings composing the entirety, between the height and projection assigned to each of these; by causing the mutules placed over the triglyphs to correspond to the guttas set below the same triglyphs, he put into his cornice the movement and rhythm, that singularly increased its effect. Mutules and guttas, as we have shown in a preceding study, are a memory of the pegs that in a wooden entablature hold the boards used to cover the joints;[1] Here both only play a purely ornamental part.

Note 1.p.378. History of Art. Vol. VI.p.715-718.

The members of that entablature recall the wooden timbers that represent a horizontal covering in the Mycenaean habitations of the most developed and most advanced type.[2] The triglyphs there occupy in the frieze the place of the decorated facing that protects the ends of the beams placed on the epistyle; to the voids existing between the ends of the beams , spaces closed by planks or stone slabs correspond

to the metopes.

Note 2.p.378. Histoire de l'Art. Vol. VI. Pl. XI.

Like the beams in the megaron, the triglyphs around the cella of the hexastyle temple only belong to the front and rear of the walls (Figs. 181, 182); the series are not continued along the sides of the naos (Fig. 200). On the contrary, one sees on all the temples that they form a continuous series on the four faces of the portico, as well on the lateral faces as on the two fronts. What are they doing there, and how can one explain their presence in that place? They do not represent a real framework there, where the wood is changed into stone. That is easily demonstrated. The members of the framework that rest on the entablature of the portico only extend above the frieze at the height of the cornice (Pl. VI, 1). Further, the members of the framework do not extend through this wall; the system of beams composing it do not appear by any sign on the exterior; in the interior alone has it left a trace in the recesses in which are inserted the ends of the beams (Pl. V). Further, to return to the wooden temple, such as might have been the primitive Heraion, would one have the beams crossing the space of the portico show their ends externally? In this temple the portico must be covered only by planks, since in the s stone portico it is only covered by simple slabs. Finally, it should not be forgotten that the entablature of the pteroma is not placed at the same height as that of the naos. If then by hypothesis, one insists on regarding the triglyphs of the frieze of the portico as the terminations of the beams of the former carpentry, let one attempt to restore those beams, to extend them from the facade in the direction of the sanctuary? They will not correspond to the triglyphs of the frieze of the pronaos; now as we proved by referring to the vestibule of the Mycenaean house, these correspond to the ends of the beams that support the covering of that vestibule; they are the only ones able to enforce their right to be regarded as representatives of the beams. For example, if one performs for the temple of Bassae, the operation that we have indicated, he discovers that those assumed beams will fall on the upper parts of the triglyphs of the pronaos (Fig. 201). They cannot be the prolong-

prolongation of those, whose ends are represented by the s same triglyphs. There is a reduction to the absurd, whose effect it is difficult to deny.

A last remark completes this demonstration in all the Grecian Doric temples; there is a triglyph at each angle of the frieze of the portico; now the post with a wooden roof did not comprise a beam set in such a manner as to furnish the form of the angle triglyph. It is easy to assure one's self of this by restoring a Mycenaean portico, such as extended around the court of the palace of Tiryns; we show it in the plan (Fig. 202) and in perspective (Fig. 203). One would n not obtain this angle triglyph without difficulty in wooden construction, as shown by the adjacent diagram, that presents for the carpentry of the portico of the Heraion two different modes of restoration (Fig. 204). The first arrangement is indicated at the left and is the most simple, what one might term the normal arrangement; but it does not furnish an angle triglyph. To obtain thes triglyph, it would be necessary to resort to that shown at the right. Doubtless it would not present to the carpenter difficulties in execution that could stop him; but if one attempted to apply it to a real temple like the Heraion, he would strongly hesitate to believe, that in practice this method was ever undertaken by the artist. The resulting ceiling gives an ungraceful arrangement, that one is truly in error to attribute to the Greek constructor, when one refers to the type, everywhere the same, of the ceilings preserved in some of his templ

The conclusion suggested by these observations has already been divined. The forms that characterize the Doric entablature has its antecedents and its origin in the system of c construction in wood; but it does not result from direct o borrowing, from a faithful and servile reproduction. It is by the sole effect of a very free copy, and intelligent copying, that the elements of the primitive carpentry are recalled in the stone temple, where they are without contact or connection with the system of the actual carpentry. There the architecture of the pronaos has for a principle the figured imitation of the frontispiece, which in the course of the heroic age indicates to all eyes the house of the n hereditary princes, protectors of the city. By their dimensio

the edifices of that importance, in which all chiefs of families gathered for deliberations and the common festivals, required the use of the powerful epistyle, thrown over a w wide vestibule open in front, and that use implied the arrangement where the frieze is divided into triglyphs and metopes. Those forms in themselves contributed to characterize the royal residence. That explains why one held to retain them in the temple, the august dwelling of the divinity, and which they even extended the application to parts of the m monument, where no necessity of construction appeared to r require its presence. One is not contented to retain them on the fronts of the two pronaoses, where their places were all indicated by tradition; they were also attributed to t the entablature of the portico, where they figured at fixed places and as purely ornamental. We can cite no more curious example of the independence with which the Greek genius has resumed the themes furnished by either the exotic models by which it was frequently inspired, or by its own past, its works of infancy or youth; it was always inventive, even in the imitative.

That alternation of the triglyphs and metopes, when it t thus assumed in the portico the character of a simple motive of ornament, has become even the abstract type of the Doric frieze. To this standard that one refers both to the frontispiece and to the lateral facades of an edifice such as the treasury of Sicyon, a true ante temple. (Pl. XIX,2). There, if one refers it to the type of the megaron of small dimensions and covered by transverse beams (Figs. 175, 176), it is only at the sides of the building that will appear t the beams; then they will not show on the facade,and consequently will not afford any pretext for inserting triglyphs there. If on a small edifice, and the triglyphs decorate t three sides of the edifice, they represent there no element of the earlier construction; at the top of those walls of the treasury, they are only a traditional decoration.

In that frieze of the portico which is no more than an o ornamental decoration, the metopes are generally almost square, except in the vicinity of the angle triglyph, where it was sometimes necessary to enlarge or reduce the area in order to place the motive. Thus by the use and repetition

of the square form was created a very peculiar rhythm, in which the eye found pleasure. It is not the same in the frieze of the pronaos of the hexastyle temples. The metopes are there very frequently longer than high.(Fig. 205). That peculiarity only requires explanation. On the front of the cella the triglyphs correspond to the ancient arrangement of the carpentry; now in that carpentry the intervals left between the ends of the beams were originally oblong, as in the alabaster frieze at Tiryns. The rectangular form quite naturally passed into the first friezes in which stone replaced wood, and by habit it was sometimes reproduced when already far from the time when that substitution was made.

In the most ancient temples, the entablature exhibits a height that does not fail to surprise the eye; in the temple of Poseidon at Paestum it forms 3/7 of the total height up to the beginning of the roof (Fig. 206). In time that height will diminish; it is much less in the later edifices. Taste has become more refined and can find more charm in different proportions; but the principal reason for that change must be especially sought in a prepossession, which must be obeyed by those that constructed the first temples of stone. The supports of the external colonnade were not between the antes, like those standing in the vestibules, connected by the architraves to the walls of the cella. They were held upright only by their own weight, and one had reason to fear that the least shock would throw them to the ground. To increase their stability, it was natural that one should have the idea of loading their tops, as done with struts on the tops of which is placed a great weight. This result is obtained by laying a very high entablature on the capitals, and consequently very heavy. In use, they discovered that due measure had been exceeded. By the precautions taken and the care with which the drums were adjusted, the column was stable by itself. Then after this experience, they believed that they could lighten the crown of the edifice, and thus give it a less massive and more elegant appearance.

Above the entablature was a wall at the two ends of the temple, in the form of an isosceles triangle, into which are

inserted the principal timbers of the carpentry sustaining the roof that removes the rainwater (Pl. VI, 2, 3); this is termed the pediment. The cornice by its service being everywhere indispensable is continued and simplified on the slopes of the pediment; but it is alone there; in a very strongly projecting member that encloses and protects this tympanum, nothing recalls the carpentry; neither modillions, triglyphs nor mutules. (Pl. VII, D). This is because this wall did not exist in the time when the roof of the structure w was entirely made of wood and terminated in a terrace.[1] On the edifices of Mycenae were no pediments. On the contrary, the horizontal zones of the entablature presented there the very clearly characterized forms that we shall know by the classical architecture; these forms have been retained in the stone temple while adapting them to other materials. As we know it, the pediment with the characteristic arrangement that it presents in the edifices of the classical age, properly belongs to the stone temple; that is why nothing indicates there the survivals, that we have indicated in the architrave, frieze and cornice.

Note 1.p.383. One can object that the temple of Hera, all whose upper parts were of wood, seems to have had two pediments, judging from the great acroteria whose fragments have been found, built before the gable roof; but it is probable that this roof and the pediments did not belong to the primitive construction. The edifice was too ancient for it not to be necessary to undertake more than once works of restoration, that could not fail to change in a certain measure the character of the building. Just as were replaced one after the other the wooden columns by stone columns, when men had to rebuild the roof, injured by time or destroyed by f fire, there was given to it the arrangement that in the interval had become the current usage. Perhaps after certain experiments, for the terrace was substituted the roof with two slopes, to which corresponded on the two facades the pediments, that were surmounted by acroterias of painted terra cotta; those at earliest were of the 7 th century. (Dörpfeld. Olympia. Vol. I of the explanatory text. p. 36).

One knows what part Grecian statuary took in the pediment, when the architect left a field to it, when he desired to

group the images of gods and heros there, placed high above the colonnade and the powerful cornice, magnificently enclosed within a rich border. Even when the pediment remained vacant, its wide base and its ascending lines from the most majestic crowning for the edifice. After the gaze of the spectator has left the ample and firm substructure, after having followed the ascensional movement of the robust columns, and after passing over the varied ornamentation of t the entablature, rises with the double inclined coping to the summit of the temple, and there it finds a point of stopping and repose in the acroteria, i.e., eo the ornamental form or in the figure that surmounts that vertex, and is detached against the blue of the sky. The same slope continues along the lateral facades even to the crest of the roof, marked by a long row of ridge tiles. Finally, to arrange on the temple a covering entirely impermeable to water and one more durable, they had recourse to the roof with two slopes; but this roof also had the advantage of terminating the roof better hhan the terrace, of giving it a nobler and bolder appearance.

Between this roof entirely covered by clay tiles,that will later become marble slabs, and the rustic terrace of the Mycenaean building with its scarcely perceptible inclination, there must have been another mode of covering, an intermediate type, the terrace in two slopes inclined toward the l lateral facades, a type born when the industry of the potter in developing allowed the constructor to use tiles. (Fig. 207, right). Between the end of the Achaian age and the 7 th century was accomplished this advance. As soon as they had tiles, men did not fail to employ them to cover the terraces to better protect the tamped earth composing them, and at the same time increasing the inclinations in order to make the removal of the water more rapid; then was commenced the designing of the wall of the pediment in the principal facades. Experience did not delay the suggestion of a perfecting of the system; one recognized that it was useless to impose on the walls and the other supports the burden of a t thick layer of clay, and they came to place the tiles directly on the carpentry, on the rafters covered by a layer of battens. Then even when this was the procedure generally e

employed for constructing the roof, men sometimes returned to the primitive method in works that required rapid execution. In 323 Athens decided to rebuild its walls. We have the decree issued on that occasion and the specification of the works to be undertaken; now it results from that description, that in the covering destined to crown that wall, the tiles must be placed directly on a bed of tamped earth. (Fig. 207, left).

Note 1.p.387. Choisy. Etudes epigraphiques sur l'architecture grecque. II, p. 70.

When he had created the temple, the architect found in t the ceramistsan ingenious auxiliary, fertile in resources; the latter not only aided him in covering the temple, but also inpplacing on certain parts an ornamentation, that it seemed must forever preserve to it that air of elegance and freshness, that the people desired to impart to that signal monument of its piety. In countries where the quality of t the stone left most to be desired, they made most general use of this procedure, that was applied most boldly to the decoration of the largest temples. If the principle of the Greek temple is the same everywhere, there are still sensible differences between the temples erected in Greece proper at Corinth, Olympia, Egina, Athens, and those of the distant colonies. The temples of Greece oveeseas have been relatively more spared by time. Outside Athens is no site on the s shores of the Egean sea, where are collected in imposing g groups edifices so well preserved as those of Paestum and of Agrigente; but no less do we regard the temples of Attica and of the Peloponnessus as the true types of the monument, which was the masterpiece of the plastic genius of Greece. The plan is there more clever and more rational, t the proportions there are more harmonious; the material is there most beautiful and the details more careful. There a and there alone does one find edifices, as in the temple of Zeus at Olympia and particularly in the Parthenon, where t the statuary has lent his aid to the architect to people with living figures all spaces where he could find room. Further,not that alone distinguishes the temples which one can term unusual; one finds there either in the plan or in the elevation variants that attest the efforts imposed by

Grecian genius to give to each of its works a personal character, while retaining the entirety of the traditional principles. We cannot undertake to notice all those peculiarities. The best means of making their importance sensible is to call attention to the plates, in which we have collected at the same scale the plans of 29 Greek temples. (Pls. XIV to XVIII). These plates require some brief explanations.

The first (Pl. XIV) groups the temples belonging to what we term the first type. That recalls most faithfully the megaron, and is its most direct descendant; it is characterized by the portico surrounding it and by the 6 columns that its principal facades present, by its double pronaos and its double internal colonnade. The latter is also doubled in height. In all temples of that category, except at Bassae, the lower tier serve to support the floor of the galleey e extending along the two larger sides of the cella, a gallery reached by stairs, whose fragments have remained in several edifices.[1] The column of the upper order beyond the architrave is the polongation of the shaft of the lower order; it continues the lines. At least that has been proved in the temple of Poseidon at Paestum, the only temple in which some of those columns are yet in place (Fig. 308).[1] It is probable that this was the same eveeywhere; but elsewhere the little order was found only in the state of fragments lying on the ground.

Note 1.p.388. There are notably traces of these stairs in the temple of Zeus at Olympia, in the temple of Poseidon at Paestum, and in three temples of Agrigente; the temple of Concord, the temple of Juno Lacina and the temple of Esculap

Note 1.p.391. Labrouste. Temples de Paestum. 18‹‹. p. 8, with figures in the text.

One finds but. 8 Doric temples divided into three aisles by an internal order, the six hexastyle temples represented on this page, the Parthenon and the temple T of Selinonte, which are octastyle. If we have joined to this group the old temple of Athena on the Acropolis, this is because the state in which has been found the masonry removes the doubts concerning the internal arrangement of the cella. The two walls bordering the oblong room forming a sequence of the eastern pronaos appear to have been made to support col-

columns; perhaps there were two of these on each side, as there were four at Corinth in the hall, that forms the front and principal part of the naos (Pl. XIX).

The second type (Pls. XV, XVI) is that composed of much more numerous temples, that have no columns in their cellas; otherwise they resemble for the rest the temples of the first type. Why was not an arrangement retained, that in Greece proper seems to have been transmitted by Mycenaean architects to the constructors of the most ancient temples? No one knows; but what is certain is, that the presence or absence of that colonnade has nothing to do with the dimensions of the edifice. Where are lacking these supports arranged between the two walls, the establishment of the carpentry seems to become more difficult, and yet in temple R at Selinonte, and the so called temple of Hercules at Agrigente (Pl. XV), where the cella is as wide as in the temple of Poseidon at Paestum, there is no internal colonnade. Then on the other hand, the temple of Theseus and that of Egina, which are smaller and more easily covered, without the aid of these points of support; they are lacking in the temple of Theseus, while we find them in the temple of Egina. What is striking at the first glance on these plans is, besides the peripteral arrangement everywhere adopted, the fact that all these temples, whatever their size, are uniformly composed of similar elements externally. With but two exceptions, at least on the facade these are composed of the same number, and this number varies on the sides only within very narrow limits. The area of the temple of Egina scarcely represents one fifth of that of the temple of Zeus at Olympia; now like the great temple of Olympia, the temple of Egina has six columns in front and only one less at the side. These elements enlarge or diminish according to the dimensions that the architect desired to give to his work; but they always retain the same proportion to each other. That constancy with which Grecian architecture undertakes to reproduce thus a type always the same is one of its original characteristics; its entire system of proportions comes from that.

With regard to colonial temples, we shall indicate some of the peculiarities presented by certain temples of the second type; others will be noticed in their places, when

we draw up by centuries and countries the list of edifices that represent the evolution of Doric architecture. On a s separate page (Plate XVII), we have placed the only two temples of this order, that have eight columns on their principal facades instead of six, the Parthenon and temple T of Selinonte, which otherwise differ in so many respects. This addition of two columns on the facade could only be inspired by the desire to give a grander appearance to that entirety. To a purpose of the same kind must one attribute the singularity of the plan of this temple of the giants at Agrigente that the opulent city had neither the time nor the means to terminate. (Pl.XVIII). If we have placed it in this series, that is to render sensible the infinite diveesity of the c creations of the Greek architect.

One will note in glancing at the series of peeipteral temples, that the columns along the sides are most frequently in an odd number. This number varies from 11 on a temple at epidauros to 17 on the Metroon at Olympia, a number only attained on the largest temple of Selinonte.

We have added on the margin of these drawings (Pls. XVI, XVIII) the plans of some ante temples and a prostyle temple, with two monopteral temples on rectangular or square plans. The type of the ante temple is that which we shall study in the treasuries. An edifice recently discovered at Selinonte presents a curious variant from it (Fig. 209). No columns between the antes; nothing but a great hall preceded by a vestibule. The two transverse walls are terminated by clearly characterized antes, where interrupted by the doorways. The whole forms a rectangle 66.3 ft. long by 27.8 ft. wide. This interior has the ordinary orientation of the temples, and according to the place that it occupies behind the propyleum that had been uncovered a short time before, the a author of the discovery inclines to think that the building could only have a religious purpose. As for the type of the prostyle temple, it especially belongs to the Ionic order; but ante temples, prostyle and monopteral temples are of t too small dimensions, and most of them are of too late an epoch, that one could think of seeing in them the organic predecessorsoof the great peripteral temples of the 7 th a and 6 th centuries. One will no more seek these the protot-

prototypes of those spacious and imposing edifices, than he would seek in the rustic chapels scattered over our coasts and among our forests, the little models of the Romanesque basilicas or of the Gothic cathedrals of our great cities.

Of all the colonial temples, the temples of Paestum are those which most resemble the temples of Greece proper. T The differences are based only on secondary details. The plan of the temple of Poseidon is nearly the same as that of the temple of Zeus at Olympia. One of these temples, that called the temple of Demeter, presents a very exceptional arrangement; this temple has only a single pronaos, and in that instead of two columns between the antes, there are f four columns placed before the porch. Two of these supports correspond to the ends of the walls of the cella, and two others to those that usually stand between these projections of the structure (Fig. 210).

At Selinonte are as many as seven temples, which form two distinct groups, that of the acropolis and that of the eastern hill (Fig. 211). For lack of knowing to what deity each of them was consecrated, it has been customary to designate them by letters;[1] we conform to that usage. At Selinonte we meet with a sort of first sketch of what Vitruvius calls p pseudo-dipteral, a type that he declares he did not see in Rome, but that he difined from Ionic edifices of Asia Minor, a temple of Magnesia on the Meander, and a temple of Alabanda.[1] What characterizes these for Vitruvius is that the portico has there a single row of columns and the same width, as if the colonnade were doubled as in the dipteral. This proportion is not attained in the Doric temples of Sicily, where this tendency to the enlargement of the portico is m marked. The effect thus obtained was perhaps happier than that where the architect had adopted a more absolute system.

Note 1.p.395. We have adopted the nomenclature of Hittorf, that extends from D to R, we know not why. (Architecture a antique de la Sicile. Recueil de monuments de Segeste et de Selinonte. Measured and drawn by J. Hittorf and H. Zanth. 1870. With atlas of 89 plates). Other learned men, like Benndorf (Die Metopen von Selinunt, 1877, follow from A to G the order of the letters of the alphabet.

Note 1.p.396. Vitruvius. III. 2-6, 3, 8-9.

In temple T the columns are farthest from the wall of the cell (Pl. XVI); but the tendency thus to enlarge the space is found more or less marked in other temples of the same city, thus for example in temple D (Fig. 212). Vitruvius attributes to Hermogenes of Alabanda the invention of the pseudo-dipteral, whose theory he explains according to the Meoir of that master, a contemporary of Alexander the Great, in which he describes the edifices that he had built in Ionia and in Caria; he did not suspect that Hermogenes could have found in earlier monuments the idea of the arrangement, that he applied to the Ionic order.

The ruins of Selinonte likewise offer examples of a singular arrangement, that one finds nowhere else; we speak of these two temples C and S, where the antes are wanting (Pl. XVI). What precedes this sanctuary is a vestibule reached by an opening, whose width is the same as that of the doorway of the naos. Here is no longer anything that recalls t the facade of the megaron; one would say that is the front of a house. The architect has striven to lessen the defect. T These columns that he has taken from the porch, he has increased in number and has transferred outside in the peristyle. At one end of the rectangle and opposite the entrance, he has enlarged the portico and doubled its supports. Thus he believed that he had found means to give his temple a m monumental facade in a different manner. This same doubling of the colonnade before the entrance is found again in a v very archaic temple, in the so called temple of Artemis at Syracuse; but there the ends of the walls play the part of antes (Pl.XVI). On the three other facades, the columns are no farther from the cell than in the peripteral temples of Greece proper; but doubling the area of the portico before the pronaos suffices to impress on the edifice some traits of very peculiar character, that distinguish several Sicilian temples. It appears that sometimes in Sicily in deciding on the plan of the temple, men have had the idea that Vitruvius attributes to the architect, that he regards as the inventor of the pseudo-dipteral arrangement. It seems to have been desired to give the edifice a twofold purpose; the naos remained the house of the god, what it is everywhere; but the portico was enlarged to become a spacious promenade where

a multitude could be under shelter and circulate at ease. This was pleasant and convenient; but the edifice then certainly lost something of its severe elegance. The architects of Athens, Olympia and Delphi, did not approve of the innovation; it was only employed in Asia Minor in the different Ionic style, and by an art caring more for effect and richness than for pure beauty.

The most important of the temples at Agrigente, the temple of Zeus Olympios, varies yet more from the classical type (Pl. XVIII). For the architect who questions those grand r ruins, and who seeks to deduce therefrom the principal lines, all is a matter of surprise. What is striking at first are the enormous dimensions. Built of cut stone, the columns are sufficiently large for a man to enter and stand within the hollow of one of the flutes; yet what is still more astonishing is the strangeness of its arrangements. The temple is pseudoperipteral in the proper sense of the word; but w what we have not seen at Selinonte, the columns on the two principal facades are seven in number, and these supports, like those also of the lateral porticos, cylindrical externally and rectangular internally, are engaged in a wall that extends around the promenade. This wall fills the intercolumniations. It appears that only two of these remained open at the eastern end to give access both to the sanctuary and to the wide gallery that surrounded it on all sides. The arrangement of the cella was no less peculiar. The interior was divided in three aisles of nearly equal width by massive pierr joined together by a thick partition of stone. Above these piers, instead of the upper order, , that supports t the ceiling in the great temples, seem to have been statues of atlantes;[1] from the remains of these figures scattered over the ground among the ruins, the edifice must have received the name of the temple of Giants, by which it is known in the country.

Note 1.p.403. Nothing remains of the arrangement of the upper parts of the building; then by hypothesis is assigned to the atlantes the place attributed to them here; but this conjecture is still that most probable of all ..at have been made on this subject.

Without leaving Sicily, we could much extend this list;

the constructors of western Greece seem to have undertaken the task not to copy servilely the models offered them by the most celebrated edifices of the mother country. Have the attempts that they made to attain originality always b been crowned by complete success? In these essays at partial invention, is there not sometimes betrayed an ambition, that deceives itself in the effect of the methods proposed? Is there not something called provincialism in literature? We can only propose the question here without solving it. It suffices us to have given by the examples cited above an i idea of the independence with which in those distant quarters of the Grecian world, the architect has treated the theme, whose fundamental elements were furnished to him by a his predecessors, by those artists who created the type of the Doric temple, much before those colonies were founded.

In this Chapter we have already had occasion to refer to the plates without text, where are presented the results of what we term the analytical study of the Doric temple. (IV-VII). Those plates form a series that will be continued in succeeding volumes, and which will permit one to follow the development od Greek architecture in its two principal modes. We shall give here very briefly some necessary indications; they will give the reason for the order in which those representations succeed each other; each of them will be definite; one will know the subject and the meaning, and can appreciate their interest.

Explanation of Plates IV to VI.

IV. The plate represents a birdseye perspective of the Heraion after the general drawings of Dörpfeld. (Olympia. Baudenkmäler. Vol. I). The edifice is cut at about the height reached at the time of the excavations by the existing parts of the work. There are shown the peculiarities that characterize the substructure of the temple and the construction of the walls of the cella. The columns are figured with the differences in diameters that an accurate measurement of the temple allows to be given. The Heraion is the most ancient Greek temple that we know; now as proved by t the view in question, it already presents the three essential traits that characterize the Doric temple, such as it appears in the edifices of the 5 th century in its noblest

and most finished form. Those traits are:-- 1, the peripteral arrangement; 2, the coexistence of two pronaoses, in front and in rear; 3, the presence of an internal colonnade.

V. Birdseye perspective of the temple of Poseidon at Paestum according to the measurements of Labrouste. The edifice is cut for the cella above the frieze and for the sides in the course above the cornice. For the rear facade, the view gives the tympanum and the copings of the pediment. As they still exist in the different courses, there are indicated everywhere the recesses, that served for inserting the timbers of the carpentry. What especially results from this view is the independence of the two entireties that form the portico and the cella.

VI. Restoration in birdseye perspective of the carpentry of the temple reconstructed according to the gains indicated in Plate V. Fig. 1, a general arrangement and construction of the portico surrounding the temple. Fig. 2, the ceiling of pronaos and cella. Carpentry of pronaos . Carpentry of the portico.

VII. Figs. 1 and 2. Roofing of painted terra cotta. I. tiles and cresting of the treasury of Gela, perspective according to the geometrical drawings of Dörpfeld. (Olympia. Baudenkmäler. Vol. I, pl. 41). 2. Tiles, gutter and upper corona of temple C at Selinonte in perspective according to the geometrical drawings of Dörpfeld. (Ueber die Verwendung von Terrakotten am Geison und Dach griechischer Bauwerke. III)

Fig. 3. Restoration of the wooden coffers of the portico of the temple of Paestum.

Fig. 4. Construction and details of the same coffers.

Fig. 5. Marble coffers of temple of Theseus.

Fig. 6. Construction and details of the same coffers.

Fig. 7. Coffers of the lateral porticos of the temple of Bassae according to Blouet. (Expedition du Moree, Pls.15,16).

A. Covering and central acroteria of the temple of Egina, rear view according to Durm. (Handbuch, p. 153).

B. Same acroteria, front view.

C. Angle acroteria of the temple of Egina according to Durm. (Handbuch, p. 155).

D. Angle of temple C at Selinonte, perspective view according to the geometrical drawings of Hittorf. (Architecture

antique de la Sicile, pls. 22-26).

E. Temple of Egina. Perspective section of the pediment, showing that the figures are detached at the back.

5. The Treasuries.

In the principal religious centres of Greece and around the great temples, that of Zeus at Olympia, those of Apollo at Decphi and at Delos, one finds arranged in groups on a terrace or along the sacred way or the route traveled by t the processions to reach the thresholds of those illustrious sanctuaries, are small edifices in which by their form and by the inscriptions collected there, also by the position occupied on the ground, are recognized what Pausanias calls the treasuries. (Plate XX).[1] There the Greek cities deposited behind grilles and gates, that could be opened only by the aid of the guardians appointed to that office, those votive offerings which could not be exposed in the open air without injury; there were piled the statues, reliefs, steles with their dedications, coffers inlaid with ivory and precious metals, vases of gold and silver. This name of treasury in those sacred places was that applied preferably to buildings of this sort, which it suited in all points. Polemon, a traveler more ancient and more learned than Pausanias, employed the word temple[2] for these edifices, in w what he wrote on Olympia. Indeed, by their purpose as by their appearance, the treasuries were likewise true temples in their way.

Note 1.p.407. The figures on these paltes are all borrowed from the paltes of Vol. I of the Olympia (Baudenkmäler); but they are presented differently. 1, Terrace of the treasuries. (1, of Sicyon; 2, 3, unknown cities; 4, Syracuse; 5, Epidauros; 6, Byzantium; 7, Sybaris; 8, Cyrene; 9, Metaponte; 10, Selinonte, 11, Megara; 12, Gela; XIII, the Heraion; XVI, t the Exedra; XV, the Metroon).-- 2, perspective of treasury of Sicyon; 3, plan of treasury of Gela; 4, plan of treasury of Megara; 5, plan of treasury of Sicyon; 6, little treasury near that of Sicyon; 7, capital of ante of treasury of Megara, perspective; 8, engaged column of treasury of Gela).

Note 2.p.407. Fragmen. Hist. Graec. of C. Muller. Vol. III. p. 108:- Polemonis fragmenta, no. 2?. Polemon mentions the naos of Metaponte and the naos of Byzantium, as well as the

offerings contained therein. Then one cannot doubt that there were two treasuries there.

Indeed the treasuries were born from the same sentiment as the celebrated temples around which they successively arose like so many annexes. Doubtless the treasories were not like the temple itself the proper house of the god; yet the god was present there in the sense that he was the owner of all valuable objects contained in that chapel; he had there his stores and his equipment. In this way the treasury participated in the religious character of the temple; it was like it, the monument of the piety of an entire people. The resemblance does not stop there. On both sides the arrangements are similar in their main lines. Certain treasuries are only composed of a simple square room (Pl. XX,6); but where the edifice has found its entire development, it consists of two rooms like the temple, a rectangular chamber, the naos, and an open vestibule, the pronaos (Pl. XX, 4, 5). The difference is in the very reduced dimensions of the treasury; so that the column does not play here such an important part, as that attributed to it in the temple. The cella of the treasury is very narrow; there is no need of columns placed in the interior of the room to support its ceiling. The vestibule is in the same proportion; it suffices there for two columns set between the ends of the walls, that are decorated by antes of very careful execution (Pl. XX, 7). Finally, there is no place to surround these narrow cellas by an external arcade, a docoration that would not have been in accord with the smallness of the buildings. 5 Besides, to enlarge the structure thus, space was lacking; it was very sparingly allotted in the sacred enclosure, that was even encumbered by being filled by secondary temples, porticos, altars and statues. Each city of some importance wished to have its chapel; but it must be contented with a very limited area. The Treasuries were crowded against each other, almost to touch; they left only narrow passages between them at the sides. Likewise even where there was space to place a portico in these passages, it would not have been visible. One could find a free space to erect columns only on the facade before the vestibule; again, where are found assured traces of a prostyle arrangement, it is shown that

this was added later[1] That is certainly the case for the treasury of Gela at Olympia, as demonstrated by the comparative study of the fragments of the cella and of those of the portico (Pl. XX, 3). There the portico is later by about a century than the body of the edifice; the masonry differs in the two parts. Perhaps what gave the idea of that addition was the square form presented by the cella. In adopting that form, they ensured a more spacious area for placing the offerings; but even if the lateral walls were extended, one would not have thus obtained an arrangement as familiar and consequently as pleasing to the eye as that of the megaron; the appearance remained awkward and cold. They desired to correct this defect by erecting before this chamber a colonnade, that was connected to the principal building by two columns attached to the ends of the walls of the naos. (Pl. XX, 8).[1]

Note 1.p.408. In the restored plan of the terrace of the treasuries given by M. Laloux, several of the treasuries present the prostyle arrangement. (Laloux and Monceaux. Restauration d'Olympia. 1889. p. 122, 123); but these restorations do not seem to be authorized by drawings made at the place. (Olympia. Tafelband I, Pls. 31, 32). Only at the treasury of Gela, the supports of this portico have left their impressions on the stylobate.

Note 1.p.411. Other treasuries, for example that of Metaponte, approach the square form.

Everywhere else the type, to which adhered the architects of the treasuries of Olympia, is that which Vitruvius calls the ante temple (Pl. XVI). The temple and the treasury came from the same architectural type, that of the megaron, a type that the treasury could reproduce in its most elementary form, according to its subordinate function and small width; but the temple existed with its essential characteristics long before the time when the first treasuries were built; the two regarded as most ancient, those of Sybaris and of Cyrene, appear to date at the middle of the 6 th century. By considering only the plan of the treasury, one would be tempted to find for it an appearance more archaic than that of the temple; but that appearance vanishes, when one measures and restores it, and attempts to represent it

in elevation, as it was at Olympia and at Delphi in the most careful examples. One then sees it distinguished from the contemporary temples only by its very reduced dimensions, and by the simplicity of its general arrangement; but it r receives the same decoration, one as rich and composed of the same elements. Painting applied on the stucco colores the coffers of the ceiling and the different members of t the entablature, when the stone is not concealed beneath coverings of polychrome terra cotta, as on the treasury of Gela. The Doric frieze extends above the architrave on the facade; even sometimes as on the treasury of Sicyon, the r row of triglyphs continues under the cornice entirely around the edifice (Pl. XX, 2).[2] Like the temple, the treasury has a pediment. In the tympanum of one of these pediments, that of the trasury of Megara, the sculptor has grouped figures that arouse the idea of the power and triumphs of the god revered at Olympia; they represent the victory that Zeus obtained over the Giants, powers of disorder and of evil.

Note 2.p.411. Olympia. Tafelband I. pl. 28. View of the larger side.

We have borrowed from the ruins of Olympia all the examples, that have served us in giving an idea of this normal type; this is because the treasuries of Olympia are the only ones yet accurately described and illustrated in their entirety and details. At Delos between the temple of Apollo a and the portico of the horns, there have been measured the traces of six little edifices that appear to have had the same purpose. In general they took the form of the temple with antes; but we know them only by a general plan on which the arrangements are indicated at a very small scale.[1] As for Delphi, we know from Pausanias that the treasuries of the principal Grecian cities there bordered the sacred way that ascended to the temple of Apollo, and to judge from the treasury of the Athenians and that of the Cnidians, which recent excavations have so fortunately uncovered, these chapels were more sumptuously ornamented at Delphi than at Olympia, the sculptor lent his aid to the architect more largely there; but if the reliefs that carved have already commenced to attract the attention of archaeologists, there have yet been published neither plans nor elevations of th-

those buildings. According to the brief reports of M. Homol tnese on the whole present the same characteristics as thos accompanying the other great sanctuaries of Greece. The discoveries that France has made at Delphi, when we are permitted to use the work so impatiently expected, will not compel us to change anything in the disposition of the treasuries that we have given.

Note 1.p.412. Holotle. Les travaux de l'Ecole francaise d'Athenes dans l'ile de Delos. Pl. I (In Coccelition des C conference de l'Exposition internale de 1889. 1890).

6. Foundations and Stylobate.

Foundations are required for the temple; if it had not been solidly seated in the ground, the equilibrium of the structure vould have been at the mercy of the least settlement; the harmony obtained by subtle combinations and by careful execution would soon have been destroyed. How did the Greeks undertake to guard against that danger? Is the care for perfection that one admires in many of their works marked as strongly in the subterranean parts as in the visible portions of their edifices? Data are wanting to reply to that question; in the course of the excavations that have relieved more than one temple from its ruins, men have had occasion to lay bare its foundations; they have been able to study them.[2]

Note 2.p.412. Most of the facts given by us are borrowed from Durm (Die Baukunst der Griechen, 2 nd edition, 1895, p. 66-71). In the Chapter of that excellent manual entitled Fundamente will be found more details and Figs. than are c comprised in the plan of our book. We have given here only the essentials.

Where as in Sicily, the temples are built of a very coarse tufa, the same stone was utilized for the body of the structure and the foundations. On the contrary, when the temple was of marble, they were contented with a more common material for the latter. Thus at the Parthenon the stone for t the courses buried in the earth was not taken from Pentelicos; it was brought from the quarries of the Piraeus, nearer and more easily quarried; it is a very compact limestone. Nothing more natural; all that one has the right to demand from the material used for that purpose, is that it resists

well the pressures supported and the dampness of the ground. This same character of economy is again found in the arrangements that were adopted for the lower construction of edifices; the architect has contented himself with the strictly necessary. There are foundations only beneath the structure; the voids in the monument correspond to voids in the foundations. A first wall bears the stylobate; other subterranean walls correspond to the walls of the cella and those that form the pronaos and opisthodome.(Fig.213, Plate IV).

These same walls are far from presenting everywhere the kind of masonry, that seems able to give the most perfect solidity. There are some in which cut stone appears only in the form of piers between which the spaces are filled by r rubble set in a mortar of mud. Elsewhere those voids are o only filled by rubbish and stone spalls, cast in at random. Such procedures betray a certain haste; if they do not seem in general to have compromised the stability of the temples, it is because the constructor has found there almost always the living rock at a very slight depth; the consistence of this rock furnished the best of all bases for its foundations. Unfortunately it did not everywhere present a horizontal surface; its crest could form a broken line or incline rapidly in places. They then saw themselves required to follow it in all its variations, which led to giving the substructure very unequal heights in the parts of the structure. This is what we shall notably find, when we study the Parthenon. We shall see to what depth it was necessary to descend on the western front end and at the southwest angle of the temple to reach the rock, on which they desired to place t the foundations of the powerful edifice.

One cannot cite another example of such a considerable w work; but still there are differences that result from the form and composition of the ground. The front part of the Heraion of Olympia has for ground the bed of hard and compact sand; thus it has no foundations there, so to speak; in the pronaos these are reduced to one sunken footing course beneath the last visible course. On the contrary toward the west, the temple is placed on a bed of gravel and pebbles brought by the torrent. From the point where that deposit begins, the foundation assumes importance; beneath the

stylobate and the wall of the cella it has a depth of 8.5 ft. and a width of 12.7 ft. (Plate IV). At Delphi, it was found with surprise, that the temple of Apollo was placed on a series of low chambers and corridors, that formed a sort of subterranean story beneath the stylobate. Although the monument belongs in a distant age, all necessary precautions were taken; it also seems singular, that in certain edifices of more recent date such as treasuries, the foundations were executed with visible negligence. There are some in which they are only made[1] of great pebbles cast in disorder beneath cut stones. Those chapels with their short columns and very thin walls were not heavy to support; besides they were all grouped on the same terrace. That rested at the rear against the mass of the hill, and in front strong retaining walls enclosed its entire length. This was there a common base for that series of buildings, which ensured their duration.

Note 1.p.414. Durm, Fig. 49).

If where the temples have been erected on the rock, the explorer has usually found every facility to inspect the f foundations, this usually becomes very difficult, when he attacks edifices, that were built on the low and wet plain. If one desires to go very deep, water invades his trenches.[2] That occurred in 18/_ to Wood in his excavations at Ephesus. It would have been very interesting to be able to closely examine the substructure of the celebrated temple of Artemis. One would like to know how the Greek architect modified his procedures to adapt them to conditions so different from those ordinarily employed in his work. As Pliny assures us, is it true that the reason for the choice of that site was the idea, that the edifice established on that marshy ground would thereby be better protected against earthquakes? We are ignorant of this; but there was preserved the memory of works executed for the purpose of creating an artificial bed in that muddy soil, on which to place the foundations of the temple. What served to compose that bed, it is related,[1] was a combenation of pulverized charcoal and locks of wool. The assertion may seem strange; yet it does not seem entirely inaccurate. At the very bottom of wells sunk against the foot of the wall of the cella, Wood at least found charcoal,

if not wool; that formed at those points a layer of about 2.76 ins., which was comprised between two slightly thicker layers of a sort of cement or mortar. As for the foundations properly so called placed on that triple bed, they were only made of stones of small dimensions, where they were e examined.

Note 2.p.414. Wood. Discoveries at Ephesus, including the site and remains of the great Temple of Diana. p.258-259.

Note 1.p.415. Pliny. N. H. XXXVI. 21.

We could multiply these remarks; they would all leave the same impression. The Greek constructor has not been inferior to himself in that part of his task; but he did not devote investigation and luxury to it. Perhaps except the Parthenon, where all parts of the work and even the least details manifest the high ambition, that presided over the noble enterprise, he was satisfied by the strictly necessary.

With the stylobate, which is the visible base of the edifice as the foundation is its concealed support, the execution of the masonry becomes more constantly regular. From the time that the building commences to leave the ground, the architect imposes on the workmen methods in accord with the character of the monument, that the city consecrates to the god, beneath whose protection it is placed by the erection of the temple.

Everywhere a series of ample steps connects to the ground the top of the stylobate, the platform on which rests the feet of the columns; but those steps do not have the same number everywhere. In some temples of Sicily there are five and even six; the last figure is reached in the temple of Zeus at Agrigente. Temples C and R at Selinonte have four. (Plate XXI, 3).[2] One counts only two on the temple of Hera at Olympia (Plate IV), and on the temple of Theseus at Athens. There are three on the Parthenon and on most temples of the 5 th and 4 th centuries (Plate XXI, 1 to 10). With three steps is obtained the proportion between those continuous substructures and the rest of the edifices, that best satisfies the eye of the spectator; but these variations only have a secondary importance. The principle always was the same, the architect always sought the same effect, when he inserted the stylobate between the ground and the

living works of the temple.

Note 2.p.415. Plate XXI, 1. After Labrouste, Les Temples de Paestum, pl.III. -- 2, after Blouet, Expedition de Moree, pl. 73. -- After Antiquities inedites be l'Attique, Chap. Vi, pl. 30. -- 4, after Ant. ined. chap. IV, pl. 4.-- 5, after Hittorf, Architecture ant. de la Sicile, pls. 22, 23. 6, Durm, Fig. 55. -- 7, Durm, Fig.55. -- 8, after Hittorf, Arch. ant. pls. 36, 37. -- After Garnier, Temp. de Jup. panhell, Plas. 2, 8.-- After Döpfeld, Olympia. Baud.I,pl.8.

On some edifices these steps often have unequal heights. Thus on one of the temples of Selinonte, the steps measured from the ground have successive heights of 15.36, 17.72, 23.23 and 19.29 ins. Where there are only two or three, they have the same heights, that according to the importance of the monument vary from 15.75 to 23.62 ins. Most frequently they present a series of plane surfaces cut at right angles. Elsewhere and particularly in several monuments of Italy and Sicily the steps present a less simple arrangement. At Paestum and Nemea, behind each tread parallel to the ground is noted a recess sunk in the riser (Pl. XXI, 1, 2). Perhaps it was desired to mark better the separation of the steps by this band of shadow. Elsewhere the tread is slightly hollowed and stops at a little border formed by the vertical riser (Pl. XXI, 4). Again elsewhere there is a swell at about the third of the riser (Pl. XXI, 3). On other stylobates lower recesses are not continuous; they stop at certain distances, so that from top to bottom, the vertical joints may be made on a plane surface (Pl. XXI, 5). Those examples were not followed by the Attic masters. At Egina, the temple of Theseus, and at the Parthenon, the steps are plain (Pl. XXI,

Note 1.p.416. Durm, Baukunst. Fig. 55.

Note 2.p.416. In reality, the faces that appear horizontal are not actually so; they present a very slight enclination intended to facilitate the flow of water.

Whatever the profile, these steps were too high to afford convenient access to the platform of the stylobate. To reach it in that manner would be to execute a regular scaling, as I have frequently proved at the Parthenon. It is necessary for one to be able to enter or leave the temple without imposing on himself an effort, that could not fail to be pain-

painful. This result was obtained by various means that can be reduced to three principal systems. Here before the principal facade the steps are recessed, so that there are two risers in height to each step (Pl. XXI, 8). There instead of stairs extending the entire width of the facade, one finds a sort of flight of steps attached to the front edge of the stylobate for a part of its length (Pl. XXI, 1-5). This arrangement comprises certain variants not equally happy; thus on several temples, the stairs only corresdond to the middle intercolumniation, which did not fail to give it a somewhat mean appearance. Sometimes the tread is cut in t the vertical riser of the step (XXI, 7); sometimes it appears attached as an added piece against that face (Pl.XXI, 6). Finally, there is a last type, presented by the temple of Egina and that of Zeus at Olympia among others (Pl.XXI, 9, 10); the stairs are there replaced by a continuous ramp with a gentle slope; access to the sanctuary thus becomes easier than by a stairs. In the temple of Zeus the ramp is flanked by side projections; thus in a certain measure it is accessible not only by the edge of its slope, but also at its two sides. At the Heraion the stairs are found at one side, being located at the southeast angle (Pl. XII), an arrangement that one believes can be explained by the place occupied by the altar of Hera, outside and south of the temple.

As a general rule, the columns and the walls of the temple rest directly on the stylobate. There is only one exception to mention, that furnished by the temple of Zeus at Agrigente. There alone those steps that give an unusual height to the substructure, and there is still a moulded plinth a sort of supplementary stylobate, that extends at the base of the wall on which are engaged the half columns of the exterior, those colossal columns, which with their capitals were nearly 62.3 ft. high.

We shall not speak here of the artifice by which the Greek architect has given a slight convexity to lines, which produce to the eye the effect of straight lines, like those of the stylobate. These curves have been mentioned and studied only on edifices of the 5 th century; they are particularly on the marble temples of Athens. We shall have to seek the

reason for it when we treat the art of the age of Pericles.
7. The column.
The column (cnion in the current dialect and more particularly stylos in the technical dialect) is a pillar, a support with a horizontal section limited by a circumference. In the edifices of the Mycenaean age, it was of wood. We n have stated for what reasons about the beginning of the historical period, the architect adopted the mode of giving to the stone in his structures a part more important, than it previously had; we have shown how in the column must first be entirely made this substitution of one for the other material. The first columns of the new type were cut in a single block; thus one had as a form the equivalent of the trunk of a tree. These monolithic columns are still found in the old temple at Corinth (Pls. XXII, XXIII) and in the so called temple of Artemis at Syracuse (Pl. XIII). However as t the dimensions of the edifice increased, and with them the height of the supports, it became more difficult to adhere to monolithism; above a certain weight, the transportation and hoisting of these members would have required a too painful effort. It seems that sometimes that difficulty was perceived in the course of the construction itself, to undertake in the full work to solve it. In temple C of Selinonte and in that of Egina, some columns are monolithic; the more numerous others are made of several blocks. Then men came to compose the shaft of several blocks superposed on each other (Fig. 214). Each of those blocks was cut in view of the place, that it must occupy in the whole; thus the architect came to give the shaft the desired curvature and t that slight inclination toward the interior of the edifice, whose reason and effect we shall have to explain. Those blocks were fitted with sufficient precision, for the form of the column to continue from bottom to top without breaks in the line of its contour. This unity of the column and drums was obtained by procedures, that will also be perfected in Attica in the marble temples of the 5 th century, but which in the most ancient temples already witness the care, that the Greeks devoted to the execution of their works. The drums are especially kept in place by their own weight and by the clost contact, that they succeeded in producing between

the bedse In each middle portion, the middle part was only dressed with the point and formed a slight depression, around which extended a projecting ring; the contact only occurred between the drums on the surfaces of those rings. M Menendeavored to make those surfaces as smooth as possible. Finally, to prevent all chance of displacement, by creating a mechanical connection between the drums, they were joined together by dowels of wood or of metal.

Monolithic or composed of several drums, the Greek column is always fluted; when it is found to be smooth, as at Segeste (Fig. 180) and in some other edifices, this is because the edifice was unfinished; in that case one nearly always finds the flutes started at the top and the bottom of the shaft. The workyard was abandoned, before the work was completed after being laid out. If in the temple of Demeter at Paestum, the first of the shafts of the internal colonnade is without flutes on a part of its circumference (Fig. 215), that is probably with the intention for that surface to serve for inscriptions.

We do not have to define here the fluting; we have already met with it in Egypt, Assyria, Cappadocia, Persia and Mycenae.[1] It has seemed to us very probably that it was first used on wood, wrought with the gouge. However that may be, since that moulding has been employed everywhere in nearly the s same fashion, it must render a service whose importance is incontestable. This is because at the first glance the spirit of the artist seized on it with one of those rapid intuitions, of which he has the secret. With the channels that groove it, the fluted column offers to the eye a surface w with a wavy horizontal section, whose development is entirely different from what it would be for the contour of an entirely smooth shaft of the same diameter, and that makes it seem stronger than it really is. The play of light produced on its surface and the dark lines drawn there have more vigor, the more vivid the light that strikes it, placing accents thereon, which give it an appearance more frank in consistency and firmness; but while enlarging the column, the fluting does not make it heavier. Entirely the contrary, the glance of the spectator is attracted to those vertical lines, which all tend toward the capital; it follows them

and ascends with them. This artifice renders more apparent the ascensional movement of the support; by this it better accents its function, and marks more clearly at first sight its place in the entirety; thus it very effectively contributes to the general expression of the edifice.

Note 1.p.424. Histoire de l'Art. Vol. I, p.549-550; II, p. 270, Fig. 110; III, p. 461, Fig. 337; IV, p. 695, Figs. 314, 321; V, p.457-488, Figs. 292, 311, 312, etc.; VI, p.525, F Figs. 201, 204, 205.

The concavity of the flutes is formed by an arc of a circle in the most ancient temples of Selinonte and in that of Metaponte (Pl. XXIV, 8, 10; Fig. 216)[2] -- elsewhere the curve is elliptical (Pate XXIV, 9; Fig. 217). This arrangement has the effect of rendering the edges finer and more nervous, as it were, and tends to prevail as the art becomes refined. (fig. 218). In the Doric order they are tangent to each other and are only separated by sharp edges. That rule is but rarely departed from, as for example at Selinonte, where in the pronaos of temple S, there are narrow flat bands (fillets) between the flutes (Fig. 219). In one of the treasuries of Olympia are found beads, rounded or otherwise arranged; they are on alternate edges (Pl. XXIV, 11). The number of flutes is always even; it varies from 16 to 24.[1] Twenty is that most frequently found; 24 is only a very rare exception. It further does not seem that there is to be sought a ratio between the number and the age of the temple. At the temple of Poseidon at Paestum, the column has 24 flutes, a and this monument is less ancient than two temples of Selinonte and the temple of Corinth, where there are 20 flutes; but on the other hand are counts of but 16 at the temple of Sunion, which dates only from the middle of the 5 th century.

Note 2.p.424. Pl. XXIV, 1 to 12. Capitals of the old Doric temple of Tiryns. Schliemann. Tirynthe. p. 275.-- 2. Temple of Metaponte. Capital; De Luynes and Debacq. 13,14. Annulets of the capital are profiled after De Luynes and after Sante Simone (Lacava, Topografia etc. Pl. X).-- 3, temple of Corinth, and 15, profile of the annulets after Döpfeld (Athen. Mitt. 1886. Pl. 8. -- 4, capital of temple D at Selinonte. -- 16, 17, 18, profiles of annulets and of the gorge. After Hittorf. Archit. ant. etc. Pl. 32. -- 5. Capital of

temple S at Selinonte. 19, 20. Sections of the annulets. H Hittorf, Pl. 55. -- 6, capital of Temple C. 21, 22, Annulets of the echinue and the shaft. Hittorf. Pl. 24. -- 7, capital of temple of Poseidon at paestum. 23. Section of the annulets and of the echinus. Labrouste. Pl. 9. -- 8, plan of the flutes of the column of Temple C. Hittord. Pl. 24. -- 9, c column of temple of Poseidon at paestum. Plan of flutes. Labrouste. Pl. 10. --10, column of the naos of temple S. Plan of flutes. Hittorf. Pl. 55. -- 11, column of the treasury of Syracuse at Olympia. Plan of flutes. Olympia. Pl. 24.

Note 1.p.429. As exceptions to custom, 18 flutes are indicated in the pronaos of the temple of Assos, 28 on a column found among the foundations of the temple of Ephesus, and 32 on two shafts of Samos described by Ross (Reisen). One will note that excepting 18, all those numbers are multiples of 4. G. T. Clarke. A Doric shaft and base found at Assos. (Am. Jour. of Archaeology).

This diversity that we have mentioned in the composition of the column and in the number of the flutes, one again finds in even the form of the support. No column does not diminish from the base upwards or is not smaller beneath t the capital than at its base; but the profile of the shaft is always far from being always the same. The variations that it presents can be reduced to two clearly characterized types. Sometimes the column has what is termed an entasis, i.e., the outline presents in its height a curvature very perceptible to the eye. This line belongs to one of those open curves, such as the hyperbola or parabola, that are not easily distinguished from each other, considering the condition in which the monuments are today. It is said that the column characterized by this line has something of the appearance of a sack.[1] The comparison may appear forced, o but it emphasizes the very peculiar character of the form so created. This entasis is most marked in the basilica at Paestum. (Pl. XXV, 3); then come certain columns of the Heraion (Pl. XXV, 2), and the columns of the temple of Metaponte (Pl. XXV, 1).[2] This entasis is only exceptionally found elsewhere. In most temples the column seems to have no entasis. At first sight, it gives the impression of a simple frustum of a cone. Yet even then it is not a straight l

line that forms upward the contour of the shaft; it is a c curve of the kind mentioned, but one whose rise is so short as to almost escape calculation. There again is an entasis, but one scarcely indicated; the effect is only perceived by a certain effort of attention. Yet it is no less needed to animate the column in a way, and however massive it may be, to give it an air of elegance and of living elasticity. Whatever the profile of the column, the flutes on it are always intersected at a small distance from the capital by one or more grooves of slight depth, that extend around the shaft. These are called annulets or fillets. Sometimes the f fillets are only at the top of the shaft, where it joins t the capital (Pl. XXIV, 2). Most frequently one or several incisions are placed a little below and cut off there a sort of necking (Pl. XXIV, 3, 4, 5, 6, 7). With the habit of animating everything and of personifying everything in nature and art, the Greek mind was pleased to compare the column to the human body; it even went so far as to give it a certain sex, according as it belonged to a certain order. For itself, the capital was the head of the column, as indicated by the term that designates that part of the support in all languages. By virtue of the same analogies, men compared to the neck of man the space bounded by the upper annulets and the incisions. The Greeks called it Hypotrachelion (literally "what is below the neck," the neck being the upper annulet, the junction of the shaft and the echinus); we call it necking.

Note 1.p.430. Durm. Baukunst. p. 86.

Note 2.p.430. Pl. XXV; 1. Column of temple called Colonne Paladine at Metaponte. After De Luynes and Debacq. --2. One of the stone columns of the Heraion at Olympia on the southwest facade. After Dörpfeld. Olympia. Baudenkmäler. Pl. XXI. -- 3. Column of basilica at Paestum, after the measurements of Labrouste.

Note 1.p.433. Vitruvius employs the word hypotrachelium several times, but without defining it anywhere. But it results from those passages, that he applies it indeed to our necking.

At the necking terminate the finish of the flutes; they do not end everywhere in the same fashion. In several anci-

ancient temples, there is between the shaft and the echinus a hollow, sometimes very marked. The flutes there terminate by penetration beneath the echinus or lose themselves there by allowing their hollow to vanish insensibly; this is the case at Metaponte (Colonne Paladini), where the flutes die around the circumference (Fig. 330). Elsewhere, and this a arrangement will prevail in the classical age, the shaft d directly joins the echinus without this intermediary hollow, and then the flutes end frankly in an elliptical curve below the separate fillets (Pl. XXIV, 7, 15).

With the joint concealed in the sinking of the incision usually commenced the block in which was cut the capital in a single piece; but between that and the direct ascent of the shaft, art had arranged a transition. The passage f from one to the other is made in several ways, according to the epoch. We have mentioned the receding moulding inserted under the echinus in some old temples; at its top it recurves outward and projects on the echinus (Pl. XXVI, 10, 11, 14, 17). It is a species of scotia with its hollow filled by a row of leaves with carved projecting ends, that recurve downward. This hollow comprises a great diversity of arrangements and ornaments, of which we have attempted to give an idea by grouping the motives collected in Pl. XXVI.[1] Here is the capital of the stele of Xenares, that according to an inscription, appears to date from the first half of the 6 th century(Pl.XXVI, 16, 17). The bases of the leaves were indicated in two colors in the hollow of the gorge; o only their points are cut in the stone, are detached and r rounded like a little collar. In the capital from the treasury of Syracuse at Olympia are no reliefs (Pl. XXVI, 16). On the little temple at Paestum to which is attached the n name of Demeter, and in the great portico (basilica), the leaves are modeled in the tufa, and above them the chisel has added a supplementary decoration at the bottom of the echinus (Pl. XXVI, 4, 7, 12). Here is a plait (Pl. XXVI3), and there are lotus flowers, palm leaves or rosettes (Pl. XXVI, 2, 5).[2] Those leaves so placed in the necking of the shaft are a heritage of the past. Mycenaean art furnished the model to classical art; we found and mentioned them in the fragments of the treasury of Athens, where they entirely

enclose the cushion that forms the lower part of the capital.

Note 1.p.434. Pl. XXIV. 1. capital from the basilica of Paestum, seen from below. After Labrouste (les Temples de Paestum, Pl. 19) and Puchstein, Das Ionische Capitell, Figs. 40, 41. The ornaments are after Puchstein.-- 2, 3, 4, 5, 6. Vrious ornaments of capitals of the same edifice. Puchstein, Figs. 40, 41.-- 7, 8. Details of capitals of the same edifice. Puchstein, Figs. 40, 41. Durm, Fig. 68.-- 9, 10, 12. Capital of the temple of Demeter, elevation and details, after Durm, Fig. 68.-- 11. Section of echinus of a capital of the same edifice, after Labrouste, Pl. XIV.-- 13, 14, 15. Capital of the treasury of Syracuse, elevation and profile. Olympia, Pl. XXIV.-- 16, 17. Capital of funerary column at Corcyra, elevation and profile. Puchstein, Fig. 39.

Note 2.p.434. M. Puchstein was the first to call attention to that curious ornamentation of the gorge of certain Doric columns. (Das Ionische Capitell. 1887. p. 48,50). It had already been noted and mentioned by Lagardette in his too neglected book (Les ruines de Paestum. Year 7). He measured and drew the details in his Pl. XI, F, G, H, I).

Note 3.p.434. Histoire de l'Art. Vol. VI. p. 727, Figs. 203, 204, 280, 281.

Did it appear to the architects, when their taste became refined, that such a decoration was not in harmony with the severe simplicity, that characterized the entirety of the Doric column? We do not know; but it is always the case in the marble temples at Athens, that one no longer finds anything resembling this complicated decoration of the gorge. That disappeared on the columns of those edifices, or to speak more accurately, it was no longer represented only by four or five annulets (armillae of Vitruvius), with a very slight projection and very close together; it is already thus in the temple of Poseidon at Paestum (Pl. XXIV.,7). These annulets form the close lines of the second collar. At the same time that necklaces hung on the neck, were there not others in feminine ornamentation, that enclosed the neck just below the chin?

The capital comprises two members, the echinus of circular plan, and the abacus of square shape. It is always a serious difficulty for the architect to succeed in establishing

between the conical shaft and the rectangular architrave a junction, that satisfies the laws of statics and pleases the eye at the same time. This difficulty was felt by the Mycenaean architect, and he thought of the sole method that can guide the artist to triumph over it. To make the transition from one form to the other, he conceived the placing of a square slab on a pad or cushion of circular plan. His successor only had to lengthen that curve of the echinus and enlarge the abacus; those changes of profile sufficed to create a masterpiece. Never has art given a solution of this p problem simpler and more elegant in the entirety, than that represented by the Doric capital. The echinus at its lower part has the same diameter ar the top of the shaft; at its top, it is circumscribed by the four sides of the area of the abacus. The two surfaces join thus; there is no void except beneath the four corners of the abacus, the overhang.

In the most ancient monuments, the contour of the echinus corms a very projecting curve, a bulging and soft curve, t that ordinarily ends in a slight contraction at the junction with the abacus. It is thus on the capital of a Doric temple, some fragments of which have been found in the citadel of Tiryns, on the capitals of temple D of Selinonte a and of the temple of Metaponte (Pl. XXIV,1, 11, 4, 2). At Corinth the curve has already commenced to rise (Pl. XXIV,3). On the capital of the temple of Poseidon at Paestum this r rise is already more marked (Pl. XXIV,7). On the works of the best period, the echinus is an inverted frustum of a c cone; the curve is strengthened. It tends thus yet more in the capitals of the last centuries of the classical age; it then acquires an elegance not exempt from some dryness; it lacks amplitude. If one draws a tangent to that curve through a point taken at the middle of the curve, the tangent makes an angle with the horizontal prolongation of the plane of the abacus, that in the old capitals is about 30°degrees, 45° at the Parthenon and 50° to 55° on the latest capitals.

The capital is terminated by the abacus, a square slab, whose height sometimes exceeds and is sometimes a little l less than that of the echinus, from which it has no projection or a very small one. By its mediation is arranged the transition from the ascending forms of the support to the

horizontal forms of the entablature . Thus the echinus and the abacus have distinct functions with different profiles; but no less the two form a single architectural member; they are always cut in the same block. It is otherwise only on the temple of Zeus at Agrigente. There the colossal dimensions of that edofice and the fact that the colunms are engaged there require other arraggements; the echinus and the abacus are separate pieces there, whose tails are set in t the masonry of the walls. Eveeywhere else there is a dowel, most frequently a metal bar, that connects the capital to the last drum of the shaft.(Pl. XXIV,1).

Another general rule with no exceptions is, that in the Doric order, neither the echinus nor the abacus ever receives any sculptured ornamentation. No ornaments other than those of the gorge, and in types in which Greek art has said its last word, these are also reduced to simple fillets. It does not even appear that there the brush attempted to replace the absence of the chisel. All the beauty of the capital was in the happy proportion of its parts and in the nobility of its lines.

It is not entirely the same for the capitals, that instead of entering into the composition of an edifice, either surmount funerary steles or columns intended to support a prize or a votive figure. Even then by the general character of their form, they recall the Doric capital and are attached to it more than to any other type, and present very curious peculiarities; they constitute another series. A certain n number of thesemonuments were found in the course of the excavations on the Acropolis, in the rubbish produced by t the destruction made by the Persians in the inteeior of the citadel; thus they belong almost entirely to the 6 th or f the first years of the 5 th centuries. The peculiarities of these capitals are explained by the special nature of the function that they had to fulfil. If some of them reproduce the type of the capitals of the columns of temples, others vary from it very sensibly. They are not required to establish a connection between the shaft and the entablature; t then one can dispense with giving the abacus a square form. In most of these pieces, that is a circular slab surmounting an echinus in the form of a basket (Pl. XXVI,16). Nearly al-

always the echinss and sometimes also the abacus have received an elegant painted decoration, whose motives are leaves or palmatiums; one also finds there lozenges or scales and often the fret. The ornamentation varies; it is everywhere brilliant and gay.[1] When in the time of Solon, Pisistratus or Clisthenes, some Eupatrid consecrated to the patron goddess of the city a tripod on which ivory and silver mingled their whiteness with the gleam of gold, when he dedicated to her a statue of a woman, on which ran for the entire length of the drapeey a border, whose design was detached in rose or blue on the matted tone of the marble, he desired that the pedestal of the tripod or the image should be in harmony with the richness of the offering.

Note 1.p.439. Durm. Handbuch. Fig. 70.

The painters of vases have more than once placed buildings, temples, porticos or fountains in their pictures, which serve to fill the ground and better define the meaning of the scenes, that they represent. However summary may be the indication of the forms in these sketches, it is still sometimes sufficiently precise for one to recognize there types, other examples of which have been collected in the remains of edifices. On the beautiful cratera of the 6 th century that archaeologists call the Francois vase, from the name of the discoverer, there is the image of a structure in the Doric style erected over a fountain (Fig. 221). The capital of the column there has the appearance of the hollow disc. As for the pear shaped capitals, that the same painter has given to the columns of what must be a temple in another p painting of that vase (Fig. 222), perhaps it is unnecessary to see in the form attributed to them there more than a sort of conventional abbreviation; yet at least on the votive c columns are found some capitals, that present this profile; there are some on Cyprus and at Athens.[2] One does not have fanciful architecture in those paintings, of the sort that in the frescos of Pompeii amuse the eye by their improbable proportions and their impossible caprices. One thus has a basis for also taking into account another trait of these sketches. In both the shaft has a very simple base, that seems to be only a disk similar to that on which was set the column of the palace of Tiryns and of Mycenae. That

wooden column characterized by its slenderness, we believe is recognized in the very thin column of one of the two pieces (Fig. 221). In a pavilion of light construction would have been established the fountain where women went to fill their vases; but the shaft of the post in the other edifice does not have such slender proportions (Fig. 222); it seems that a stone column there served as a model for the painter. When stone was substituted for wood in the shaft, the base which the latter could not do without became useless; yet perhaps it was not at once decided to suppress it. These designs thus attest the temporary existence of a stone Doric column provided with a base, a transition type of which no certain example is preserved in the edifices. One indeed scarcely knows what to think of a singular column, whose lower part was found in the pronaos of the temple of Demeter at Paestum. (Fig. 223). Labrouste restored it with an Ionic capital;[1] but if it has a base, that base does not present the canonical traits of the Ionic base, and further the fluting of what remains of the shaft shows no fillets; it is the Doric fluting. If one can hesitate concerning the true character of this enigmatical type, he would not feel the same embarrassment in regard to the lower part of a column with Doric flutes, that had the function of a stele in the cemetery of Assos. It was set with lead in a hole made at the centre of a large disk cut in the same rock, that served to support the monument (Fig. 224).[1] This base, that was cut away to give space for a sarcophagus of later date, was 5.25 ft. in diameter and 1.12 ft. high. The diameter of the shaft is 1.34 ft. It was broken off at 2.13 ft. above the base. It is assumed that it was about 9.0 ft. high, and that it bore a statue, of the votive inscription engraved in two flutes, there unfortunately remains only the initial word and some letters of two other words. These flutes are 25 in number; that is a peculiarity of that other antique column seems to present.

Note 2,p.439. Histoire de l'Art. Vol. III, Fig. 117.

Note 1.p.440. Temples de Paestum. Pl. XIII. Long. section.

Note 1.p.441. J. T. Clarke. A Dorci shaf found at Assos. Am. Jour. of Archaeol. Vol. II. 1886. p. 267-285.

If we have emphasized the votive columns and those of the

architecture represented on the vases, this is because both aid the historian to form an idea of the primary variety of the forms; but it is particularly as an integral part of t the temple, that we have prepared to study the column in t the role that it plays as a support, and in what it adds in beauty by the nobility of its proportions and of its pose. To comprehend what use of it was made by the science and t taste of the Greek architect, it is then proper to consider it in the edifices where it is still standing, where before the wall of the cella the shafts were aligned, and rose proudly on the stylobate, holding suspended on their heads t the weight of the entablature.

One of the most singular arrangementr that have been noted where the ruins permit systematic observation, is that the axes are out of plumb in the edifices, whose execution is most careful, particularly in the 6 th and 5 th centuries. All the columns are slightly inclined toward the interior of the monument. This will be understood from the diagram, which represents the four planes passing through the axes of the columns of the hexastyle Doric temple, meeting at a very great height to form a solid (Pl. XXVII).[1] It is scarcely necessary to state, that to render the effect more distinct, the inclination of the shafts has been greatly exaggerated in the sketch, for the angle columns this is only about 1.58 ins. for the entire height of the shaft in the great temple of Paestum and at Egina, shown in the adjacent plate, where the dotted lines indicate the direction of the plumb lines on the columns (Fig. 2, 3, Pl. XXVII).

Note 1.p.442. Pl. XXVII. 1. Theoretical diagram. 2-6, columns of the temple of Egina, according to notes of Ch. Garnier. (Le temple de Jupiter Panhellnien. 4. Equal angular inclination of the two faces of the temple. 5. Inclination perpendicular to the wall of the cell and none in the vertical projection. 6. Inclination perpendicular to the lateral wall of the cella. In these Figs. the dotted lines indicate the direction of plumb lines. 7. The columns of the temple of Theseus according to pennethorne. The Geometry and Optics of ancient Architecture. 1878. Part IV.Pl. XV,2.

This inclination is produced in two ways, according to two systems that it is important to distinguish. Here at

first is the simplest, whose application has been verified on several monuments, and which corresponds to the diagram above; (Pl. XXVII, 1); we represent it according to the temple of Egina (Pl. XXVII, 2-6). The columns of the portico are all slightly inclined on the four sides of the edifice toward the wall of the cella. In conseqence of that arrangement, the corner columns have a double inclination. It is to be noted, that if one considers the generatrices of the columns in the longitudinal and transverse sections of the temple, that those beside the nave are much more nearly vertical than those outside.

The other method is more complicated, and its use has so far been mentioned only by a single observer, Pennethorne, and in regard to a single edifice, the temple of Theseus. (Pl. XXVII, 7). There on both fronts, the columns incline toward the wall of the cella, and at the same time toward the longitudinal axis of the edifice; that inclination is the more marked, the farther the column is distant from that axis, from the middle intercolumniation. Along the longer sides of the parallelogram, the columns are arranged as in the preceding example; particularly on the outside is the inclination pronounced; it is scarcely perceptible beneath the portico. Nearly everywhere, it is revealed only by a minute examination made with instruments of precision; yet it is perceptible in the angle columns, at least by the trained eye of a professional man.

The reason for the existence of this artifice has been sought in the laws of statics and in those of optics. Both have perhaps contributed to suggest the idea of such an arrangement. In case of an earthquake, the supports inclined toward the interior of the edifice must resist beeter than vertical supports a movement of translation, that would have thrown them to the exterior. On the other hand, the wall of the cella at the Parthenon has a slight batter; it thus appears to lean toward the interior in its upper part, while because of the diminution of the shaft, the line of the column is inclined in the opposite direction toward the outside. Thus in elevation there is a certain divergence between the two enclosures of the sanctuary, the wall and the supports of the external portico. It is proposed to lessen

this contrast by inclining the axes of the columns from the vertical; the deviation was but a few ins., and the column thus seemed to follow the movement of the wall, tending to become parallel with it.[1]

Note 1.p.446. This was suggested by Durm, who rejects the other explanations (Baukunst, p. 95). Some have thought to find in a passage of Cicero (In Verrem, II, 1, 133) an allusion to this inclination, that the architect sometimes imposed on the column as a system. It appears more probable that the orator only desired to recall, that it was not easy to give rigorously vertical axes to all columns.

To give an inclination more or less great to a column composed of several drums and comprised between two horizontal planes, those of the stylobate and of the architrave, it w was necessary to resort to certain artifices, whose theory we cannot explain here.[2] By a special cutting reserved to t the two lower and upper drums, the desired result was obtained. The beds of these drums were not horizontal, and consequently these drums did not have the same height outside and inside; but the joints of the drums comprised between the extreme drums were generally parallel to each other. Further it is particularly in the Doric temples of Athens and of Paestum (Pls. XXVIII, XXIX), that one finds these wise combinations and these refinements (Fig. 225);[3] they are vainly sought in most of the temples of Sicily. We shall have occasion to return to this subject in the course of these studies.

Note 1.p.446. See Durm, Baukunst, p. 95-97, Figs. 72, 73, 74).

Note 2.p.446. Durm, Baukunst, p. 100.

On many temples, the angle columns are a little larger t than the others. Vitruvius prescribes the enlargement of t the angle columns; he even fixes at 1/50 of the diameter t the normal amount of that increase, and here is the consideration by which he justifies that practice.[4] "If these are necessary," says he, "it is because these columns are surrounded by air, and thus they risk appearing to the spectator more slender than the others, that are seen against the wall. A doubt has been expressed concerning this subject. With t the form of the temple, with the shafts so near each other

as are those of the portico, one can scarcely have occasion to see the angle column detached alone against the sky to seem reduced thereby.[5] To find the point from which it presents itself under that aspect, it is necessary to search, and still the form of the olaction in the vicinity of other buildings does not always permit one to place himself there. We agree, but has one any other explanation to give of this arrangement? The architects certainly had their reasons for taking this method. These reasons must both have been explained in one of those writings, in which they analyzed their own works, and has one not a right to think, that here as in many other pages of his book, Vitruvius is merely the interpreter of the masters by whom were created the models t that he teaches men to imitate?

Note 4.p.448. Vitruvius, III, 3, 11.

Note 5.Durm, Baukunst, p. 101.

If in the monuments regarded as masterpieces of art, the columns are neither entirely vertical, equally inclined, n nor of equal sizes, and the distances separating their axes are not uniform. There again, when one takes measures in w which scrupulous accuracy is pushed as far as possible, one has surprises, particularly in relation to archaic edifices, The dimensions of those intervals are dissimilar, according to the place that they occupy in the portico. The angle intercolumniations are less than the others; sometimes even the various intercolumniations present distances, that constitute a gradation of distances from the angle to the centre of the arrangement; that will be verified by taking the widths of the intercolumniations in the adjacent Figs., that show the extreme liberty that the architect used in locating his columns (Figs. 226,to 230). One will note in the first example, that the intercolumniations all have different widths on the facade and on the sides of the pronaos; beyond the pronaos in the series of the portico, they become sensibly equal to each other. These intervals at the sides are narrower than the narrowest intercolumniations of the facade. (Fig. 226). Further, the distance between the angle column and the adjacent columns is the same on the facade and on the sides (Fig. 227). In another edifice, the intercolumniations of the sides are all wider than the middle and angle

intercolumniations of the facade. (Fig. 228). Here on the facade the middle intercolumniation is narrower than the middle intercolumniations (Fig. 229). There in the facade the mean intercolumniations are sensibly equal; those of the sides are a little wider (Fig. 230). Such is the arrangement, that from a certain time appears to be most generally employed; until about the end of the 5 th century, one usually gives greater width to the middle intercolumniation. The angle intercolumniations have always been and will always remain narrower. In placing the columns closer near the four corners of the edifice, did men desire to strengthen these angles, perhaps giving to construction the reality, or at least the appearance of a firmer site? Or indeed is it especially the arrangement of the entablature, that reacted on that of the supports? Is this to have more facility in placing his angle triglyphs, that the architect has thus brought certain columns closer together? It is of little importance in what measure each of these inducements contributed to cause this rule to be adopted; but it is certain that it has been applied everywhere. The reduction of those intervals is more constant and more perceptible to t the eye, than the enlargement of the angle columns.

If in the same temple the width of the intercolumniation varies with the place it occupies in the arrangement, that variation is confined within very narrow limits. On the contrary, one finds very marked differences, when he compares this width in one edifice to that in another, particularly when one compares monuments belonging to very different periods of the development of the art. The ratio of voids to solids is far from being the same in a temple of the 6 th, in a temple of the 5 th, or one of the 4 th centuries. To note this, the diversity of the facts have been reduced to fixed formulas. Thus Vitruvius distinguishes five systems of proportions, which he designates by terms, whose composition even indicates that they were borrowed from the technical language of Grecian architects (Pl.XXX);[1] the unit or module, as he says, that he employs to define these systems, is the lower diameter of the column, or the triglyph in the Doric order. Here is the list that he drew up.

Pycnostyle ratio; interval of 1 1/2 modules.

Systyle ratio, interval of 2 modules.
Eustyle ratio, interval of 2 1/4 modules.
Diastyle ratio, interval of 3 modules.
Aerostyle ratio, interval of more than 3 modules.

Note 1.p.453. Vitruvius, III, 3, 1-7)

As informed by the name itself borne by the third of these systems, that is the one that Vitruvius prefers; the eustyle according to him corresponds better than the other arrangements to the requirements of construction and of circulation; it likewise gives to the colonnade the appearance that most pleases the eye. Vitruvius adds a remark concerning those: -- he says that in the diastyle the free spans of the architrave are too long; the stone of which they are made is exposed to fracture. As for the aerostyle, according to him, one can use for the architrave neither limestone tufa nor even marble; wood alone with its elasticity can lend itself to cover such wide spaces.

Vitruvius seems to attribute to Hermogenes the invention of the theory that he proposes;[2] now he lived in the 4 th century, i.e., much after the time when were erected all the good Doric temples of Greece. The elements of this theory must then have been derived especially from the study of Ionic edifices, the only ones built then, and consequently the only ones that interested then the architect. Thus as one proves when he enters the path of accurate measurements, the numbers 1 1/2, 2, 2 1/4 and 3 that Vitruvius indicates as the different normal expressions of this ratio, in no case agree with those furnished by the measurements made on the monuments themselves. That results from the following table, where the inscribed numbers represent the ratio found between the lower diameter and the interval between the column

Egeste, 1 1/5 to 1 1/6.
Selinonte, temple A, 1 1/4.
Corinth, old temple, 1 2/5.
Athens, Parthenon, 1 2/5.
Bassae, temple 1 1/3.
Egina, temple, 1 3/5.
Athens, temple of Theseus, 1 3/5.
Selinonte, temple C, 1 3/5.
Selinonte, temple D, 1 3/5.

Olympia, Heraion, 1 3/4.
Athens, Propyleion at middle, 2 3/5.
Çadacchio, temple, 2 3/5.

Note 1.p.451. We borrow this data from Durm, (Baukunst, p. 104). Also see Ch. Chipiez. Au system modulaire dans l'architecture grecque, p. 32, 33 and Pl. VIII (Revue arch. 1891, p. 1-14, 9 pls).

By themselves alone, these figures do not suffice further to give a just idea of the character of an arrangement. To define it, other elements must be taken into account, the actual dimeter of the columns, their form and their relative height. With the same intercolumniation, two colonnades might produce a very different impression, according as the shafts are short and squat or as slender as allowed by the proportions of the Doric order.

When one studies Greek architecture, and he knows its evolution from the 7 th to the 4 th centuries, by comparing edifices to which one is correct in assigning a date more or less approximate, he recognizes that this art has not ceased to modify its system of proportions, and that changes are always made in the same sense, and that they are all expressions of the same tendency. In the portico that surrounds the temple, we must indicate from this moment that the voids have not ceased to increase at the expense of the solids. At the same time that the columns become thinner and more slender, the intervals separating them are enlarged. This is proved when one measures these intervals between the feet of the shafts or at their tops between the capitals under the architrave. This last mode of measurement gives results that the eye seizes more quickly. "There is the place where the intervals are most strongly accented. The square abacus alternating with them contributes to that effect by forming a denticulation whose rhythm clearly strikes the view. This rhythm is made very apparent in the examples represented here ((Fig. 231). In the temple of Artemis at Syracuse (I), the width of the space is to that of the abacus nearly in the proportion of 1 : 5 1/2. This ratio successively increases in the temples of Poseidon at Paestum (II) and R at Selinonte. (III; Pl. XXXI). There is equality between the space and t the abacus in the temple of Zeus at Olympia (IV). The space

is wider than the abacus on the temple of Theseus (V). Finally, the width of the abacus is exceeded by one half by t that of the space on the temple of Nemesis at Rhamnus.(VI)."[1]

Note 1.p.457. Chipiez, Le systeme modulaire. p. 32-33.

The number of columns of the portico at the longer sides of the edifice varies from one temple to another. It is sometimes odd, without any rule seeming to govern the fixing of the number adopted. This results from the adjoining Table, that does not claim to be complete, but where appear the best known temples.

11 columns; temple of Asclepios at Epidauros. Metroon at Olympia.

12 columns; Temple of Egina. Temple of Sunium. Temple of Nemesis at Rhamnus.

13 columns; Temple of Zeus at Olympia. Temple of Nemea. Temple of Demeter at Paestum. Temple D at Selinonte. At Agrigente, the so called Temples of Concord, of Juno Lucina, of Vulcan, of Castor and Pollux, of Jupiter Polieus.

14. columns; Temple of Segeste. At Selinonte, Temples A and S. Temple of Poseidon at Paestum.

15 columns; Temple of Corinth. Temple of Apollo at Bassae. Temple of Poseidon at Paestum. Temple R at Selinonte. Temple of Hercules at Agrigente.

16 columns, Heraion at Olympia.

17. columns; Parthenon. Temple C at Selinonte, according to Hittorf.

In the course of the sole work that represents to us the theories of the architects of antiquity, Vitruvius employs for briefly indimating the form and character of the edifices mentioned, terms that by the intermediary of the architects of the Renaissance have passed into the language of modern architectsr This nomenclature, as we have stated, w was created chiefly according to Ionic arrangements, and certain terms comprised therein apply to types, that according to all appearance were never realized in the Doric style. Yet all these terms have entered into current use, and it is important to definc them by Figures, which will give their meaning to the reader without requiring other explanations. We have done this in Plate XXX; there will be found the temples classified according to the method of Vitruvius,

first according to the number of columns presented on the facade, then according to the places occupied in the entirety of the edifice and the manner in which they are arranged there. A third diagram, gives the graphical translation of the terms employed by Vitruvius to characterize the arrangements, according to the greater or lesser distances between the supports composing it..

E. The Ante.

We have considered the necessity in which the Mycenaean constructor found himself, of facing and protecting the ends of walls built of crude bricks or of small materials; we n have shown how he obtained this result by means of a facing of solid planks. The ante (parastas) is nothing but the stone representation of that facing. Then it presents the appearance of a sort of square pier, that to the eye at least, reinforces the ends of the lateral walls of the cella, and gives them a more solid and stronger appearance.

As we stated of the Heraion, this procedure was used to form the ante in the first peripteral temples, where the wall was made of clay bricks; wood was still applied to that wall, but when men commenced to build the temple of cut stone, there can no longer be any question of concealing the courses under an arrangement of planks. Thenceforth, the ante became a continuation of the wall; but by its form it still recalled the type from which it came.

By the place that it occupies and by the part that it plays, the ante belongs to both the wall and the column. It is the prolongation of the wall, thus where the wall has a moulded plinth as on the temple of Theseus[1], that continues entirely around the ante (Pl. XXXII, 12); but the ante being wider and more massive than the wall, is at the same t time intended to present the appearance of a support. Where the temple is without an external colonnade, as on the megaron, it aids in supporting the entablature on the facade, on the peripteral temple it fulfils the same function for the special entablature of the pronaos. Like the column it is slightly inclined in the most ancient edifices toward t the interior of the building, and it is diminished from bottom to top. By virtue of this similarity, it likewise bears a capital.

Note 1.p.461. Histoire de l'Art. Vol. VI. p. 195, 500-501, 530, Fig. 189.

Where in the order the column has a base, the ante also sometimes has its own, that presents nearly the same profiles. In buildings of the Doric style, the ante rests directly on the stylobate, the regular courses with joints continuing. Those of the wall correspond to the drums of the shaft (Pl. XXXII, 12); but they never receive flutes. Those are reserved for the isolated support. Applied to the ante, they would have falsified the principle; they would have too much distinguished the ante from the wall. Yet there are rare exceptions; thus on one of the temples of Selinonte, at the end of the wall in the place of the ante, the architect has placed three fourths of a fluted column (Pl. XXXII). In this manner of terminating the wall is a blunder that has found imitators.

Note 2.p.461. Plate XXXII, 1-4. The ante of the great portico (basilica) of Paestum, after Labrouste, Pl. 19. 1. perspective view of the ante in the transverse direction of t the edifice, and 2, in the longitudinal sense. 3. Geometrical elevation. 4. Plan. -- 5-9. Antes of temples of Selinonte, after Hittorf, Arch. Ant. pl. 79. 5. Ante of the pronaos angular perspective. 6. Another ante, angular perspective. 7. Profile of ante 6. 8. Plan of ante 5. 9. plan of ante 6. 10. Plan of ante of temple of Poseidon at Paestum, after Labrouste, pl. 10. 11. Plan of the ante-column of temple D at Selinonte. (Hittorf, Arch. ant. pl. 33). 12. Temple of Theseus, elevation of the ante on the lateral facade of the naos, after Stuart (Antiq. d' Ath.III, pl. 10), and Iwanoff (Arch. Studien, vol. 9). 13. Ante of temple of Nemesis at Rhamnus (Antiq. ined.Chap. VI, pl. 9). 14. Ante of temple R at Selinonte (Hittorf, Arch. ant., pl. 43).

Particularly by the capital, the ante differs from the column, Above the Doric column, the echinus and the abacus are clearly separated by the contrast of their forms, but have this trait in common, that in their robust simplicity they both always remain without any ornament; but the architect had no reason to repeat at the top of a wall, forms whose shapes on the column had been fixed by the imposed necessity of starting from a circular plan to arrive at a

square one. If then the crowning of the ante by its position corresponds to that of the column, it always retains by its form its separate character; yet according to the time and place, the capital suited to it presents different aspects. In the 6 th and even in the 5 th centuries, what distinguishes it in Greece and in the greater number of the timples of Italy and of Sicily, is, that it is formed by a series of m mouldings placed on a facia, a sort of slab, a series in which were introduced eggs and beads in the 5 th century. (Pl. XXXII, 1-3, 6).

In these profiles of the ante, there is one trait on which it is necessary to insist, and that confirms the explanation that we have given of the origin of the member in question. If the primitive arrangement of the ante were unknown to us, we should have difficulty in comprehending why in the edifices of the classical age, the sides of the ante are frequently of such unequal widths (Pl. XXXII, 9, 10). Such narrow faces represent the post or plank of former times, they have the small[1] thickness of those; they reproduce their arrangement.

Note 1.p.482. Histoire de l'Art. Vol. VI. p. 730-731, Fig. 324.

On certain edifices of the colonies, such as the temple F at Selinonte and the basilica of Paestum, the ante has an entirely different appearance. There the ante is square in plan (Pl. XXXII, 4, 8). One of these antes recalls the appearance of certain Egyptian piers, an analogy rendered still more apparent by the very great cavetto that crowns it. (Pl. XXXII, 1, 2). There the capital of the ante seems to have desired to contest in amplitude with the column, by means of the contrast arranged between that great cavetto and the broad abacus that surmounts it. Elsewhere in temple T of Selinonte on the pronaos, we again find this same square pier; but at its top, this presents a rich ornamentation covering the entire slab interposed between the wall and the architrave. At the bottom of the capital is an astragal composed of disks and beads. Above, the entire field is filled by the development of a single motive, a central palmatium around which wind the scrolls, that do not fail to make one think of the forms dear to the Mycenaean ornamentist. (Pl. XXXII,

5, and Fig. 231.

Where one decorated thus the capital of the ante, he frequently called the brush to the aid of the chisel. This is the case for the ante of temple T of Selinonte, where the entire ornamentation was executed in color, for that of the temple of Nemesis at Rhamnus, for that of temple R at Selinonte, and for yet others where painting served to give more accent to the relief of ornaments modeled in the stone (Pl. XXXII, 13, 14). The monuments of the Acropolis of Athens evidence the same refinement. About the middle of the 5 th c century, architects will introduce into the facia of these antes by a free and desirable imitation, a species of annulets that reproduce those of the capital of the column. The differences existing between the capital of the ante and that of the column are explained, at least in part, by a reason of art. The conditions in which appeared the ante in peripteral temples, were not the same as those shown by the column. There the ante was only visible under the portico in the half light of the pronaos. To model its capital, one did not have to count on the play of a free light. It was then only a m means of accenting that portion of the ante, of giving it a bolder contour and a richer ornamentation, where between the reliefs and the hollows of the mouldings the bands were ornamented by designs, whose outlines were accented by the different colors. On ante temples, the ante appeared in the f full sunlight on the same plane as the independent supports; but there also it found good that enrichment of the decoration. The angles of the edifice, with the crowbeak moulding terminating them and the lines of shadow that vigorously m marked the projections of the stone, thus assumed a firmness contrasting with the receding rounds of the middle columns,[1] which had the happiest effect.

Note 1.p.466. On the crowbeak moulding, the elements into which it is resolved and its decorative values, see the observations of Hittorf, Arch. ant. p. 357-359. (Pl.LXXX, ,22

The width of the front face of the ante is most frequently less than the lower diameter of the columns of the portico and larger than their upper diameter.[2] Further, there also is no absolute rule. In the same edifice the constructor n has sometimes used two different modes. On the temple of The-

Theseus, the ante of the pronaos nearly corresponds to the diameter of the column opposite it, while that of the opisthodome is much narrower. The latter was less in view; the architect has given it less importance.

Note 2.p.466. Vitruvius (IV, 4,1) prefers that the width of the ante should correspond to the deameter of the shaft opposite it; but his rule applies to the Roman ante, which is only a pilaster on which are repeated the motives of the column.

9. The Entablature.

The entablature is composed of three parts, the architrave, frieze and cornice. The architrave (epistyle) is formed of great blocks of stone of rectangular section. Each of these rests on two columns. The junction is made at the middle of the capital. Thus the architrave repeats the general form of the building, such as given by the stylobate, and it distributes on the columns the weight of the rest of the entablature and a part of that of the roof.

On small temples, the architrave could be made of a single block; but on temples of great dimensions, it is divided in the direction of its width into two and sometimes three parallel slabs. In the 6 th century it consists of two stone beams placed one behind the other (Pl. XXXIII). One divines the reason that decedid the constructor to double it. If a rupture occurred, the one beam not affected sufficed, at least temporarily, to carry the load of the rest of the entablature; further by this division, he avoided having to hoist masses handled with difficulty.

There are some edifices, otherwise in very small number, where the architrave is divided in several parts, not only in width but also in depth. That peculiarity is explained in the temple of Giants at Agrigente by the colossal character of the edifice. There are superposed three stone beams to compose the architrave, the bottom one being 3.94 ft. high, and the two others being 3.23 ft. each. This arrangement is not justified by the same reasons in certain other temples of moderate size, where on finds it, such as temple C of Selinonte and the old temple of Metaponte. The architrave is there composed of two superposed blocks. That arrangement was later abandoned, but it is proper to mention

it for the observation suggested by it. It shows that in the 6 th century in the period of essays and experiments, the architect designed his edifice without otherwise taking pa- pains to place the lines of it in proportion to the dimensions of his materials.

It is then a rule that the Doric architrave should retain in elevation its apparent unity. The sole decoration, or at least the only ornament cut in the stone, that it admits, is a band in slight relief, that borders its upper part. B Below this fillet that forms a continuous band appears, only below the triglyphs of the frieze, another fillet of less projection (Pl. XXXIII, 1).[1] Below the last fillet hang little appendages of cylindrical or conical form, known by the name of drops (guttas); they are generally six in number. Sometimes these drops are detached at the back (Pl. XXXIII, 11, 13),-- this is the same as the most ancient mode --, and sometimes they are adherent there. We have explained to what arrangement of the ancient carpentry the drops corresponded.[2] In some constructions these were changed into an ornamental motive. Men must not have delayed to lose the memory of the past played in the structure by the pins, that they represent, and they acquired the habit of inserting them with the same regular intervals on architraves that bore no frieze, for example, on those in the interior of the cella, that separate the second order from that on which it rests.

Note 1.p.467. Pl. XXXIII, 1-5. Entablature of temple R at Selinonte. 1. Perspective of entablature. 2. Crowbeak moulding that crowns the facia. 3. Plan of assemblage of triglyphs in the frieze. 4. Angle chamfers of triglyphs. 5. Axial section of a triglyph showing mode in which the upper part is formed. After Hittorf. Arch. ant. Pls. XII, XLII, XLIV. 6. Terra cotta cyma of the cornice of the treasury of Gela. After Dörpfeld, Die Verwendung von Terrakotten. Pl. IX. 7, 8, 9. Entablature of temple of Poseidon at Paestum. 7. Angle triglyph. 8. Plan of frieze showing the construction of the triglyphs. 9. Plan of architrave, after Labrouste. Pls. IX, X. 10. Triglyph of terra cotta of Selinonte, view showing section of a metope. After Durm, Fig. 88. 11. Section showing the drop placed beneath the same triglyph, after Durm. Fig. 84. 12. Plan of the channels. 13. Drop placed under a

triglyph of terra cotta. Hittorf. Pl. XXIV.

Note 2.p.467. Histoire de l'Art. Vol. VI. p. 709, 720; Figs. 309, 310, 315, 316.

On the monuments of Greek architecture as presented today to our eyes, the architrave appears as a long lintel, entirely white and bare, while the frieze that surmounts it is frequently decorated by sculptured figures, and in any case is divided by the triglyphs. By reason of even its origin and of its function, the architrave has always presented a surface less ornate and less monumental than that of the frieze. One knows that one temple, that of Assos, where the architect thought to place sculpture as on the frieze (Pls. XXIV., XXXV.); but that monument is an Asian temple, and we should not forget that in that country, art was subject to influences that we know imperfectly, and which have sometimes given a very peculiar character to its creations. In a any case, that innovation does not seem to have been approved, for it has found no imitators. If on terra cotta entablatures that came from Sicily,the posts and scrolls run on the architrave, that concerns only moulded pieces of small dimensions. In Greece proper, the architrave seems to have been sometimes painted red; but it does not appear that ornaments were ever designed on it, and that it was quite late and especially after the 4 th century, that men thought of fixing on the band by means of nails, shields of gilded bronze or inscriptions executed in great letters of metal; t those attached pieces commenced to invade the architrave o only when taste had become less refined and less pure. In the 5 th and 6 th centuries, if the fillet, regulas and drops were enhanced by color, the architrave from which these mouldings had a very moderate projection, extended while retaining the natural color of the stone or marble, without any painted or sculptured motive to interrupt its uniform and smooth extent. Thus it had a very sensible contrast between the appearance of the frieze and that of the architrave, which contributed to distinguish the Doric entablature, and that gave it its own beauty and its expressive character.

The vertical position of the architrave above the column varies with the time, as shown by the adjacent Fig. (Fig. 233). In the most ancient examples taken from the temple of

Poseidon at Paestum (1), that vertical falls in the interior of the column, whose shaft projects strongly beyond the line thus continued. At Bassae, this vertical strikes the shaft at about the middle of its height and penetrates it (2). At Egina, it only joins the shaft near its foot (3). Finally, at the temple of Nemea, the line prolonging the external f face of the architrave remains outside the shaft until it strikes the stylobate (4).

The arrangements employed at Paestum and at Nemea are then the two extreme terms of the series formed by all that have been adopted to define that relation between the 6 th and 4 th centuries. No more here than for other relations, can one establish in the variants of the theme a rigorously chronological order; but it no less remains established by the comparison so instituted, that from the beginning of Doric architecture to its more recent creations, the architrave has tended to move out on the column.

It is the same for the projection of the abacus from the architrave. That projection is much greater on archaic capitals where the curve of the echinus is very unnatural. Here we shall only examine the two extreme terms of the series. (Fig. 234). The examples are taken from temple S of Selinonte (1) and from the temple of Nemea (2). One sees that the profiles have a much greater and bolder character in the ancient type than in that furnished by the most recent edifice

What constitutes the Doric frieze and forms its originality is the alternation of triglyphs and metopes, the triglyphs being a sort of piers spaced at equal intervals between the architrave and cornice, and the metopes are rectangular slabs as ornaments, that fill the entervals between the pier

We shall not return here to the origin of the triglyph; we have stated how this motive was first suggested by the decorative facing that was received by the visible ends of the beams in the carpentry of the Mycenaean palace, was transferred and employed by analogy, even where it no longer corresponded to the internal construction of the edifice, and how it ended by appearing in the frieze of the portico on the four fronts of the temple. What finally demonstrates t that on that frieze, the triglyph is but a mere ornament, is the fact that on certain archaic temples, such as the t

temple of Poseidon at Paestum, the triglyphs do not present themselves as independent members; one finds two cut in relief on the same stone of the frieze.

The triglyphs were channeled like the columns, but their channels did not have the same section as those of the shafts, they were of a section distinctly triangular. Yet this rule comprises some rare exceptions. Thus at Metaponte on the temple called Tempio delle colonne Paladine, the architect desired to innovate. The section of the channels of t the triglyphs is a circular arc. A narrow groove sunk at t the bottom of the channel and a narrow fillet projecting f from the ground of each panel gives this triglyph a very peculiar appearance (Fig. 235). On the most ancient monuments, for example on the temples of Paestum and most of the temples of Sicily, they stop at the crossing of the narrow band surmounting the whole, in curves whose trace changes from one edifice to another (Pl. XXXIII, 1, 4, 5). There is very great variety in the sections of these channels; but what is never lacking are the channels themselves, with the lines of shadow that they draw on the surface of the frieze. To designate these grooves and the pier itself, to which t they give such a peculiar appearance by their depth and by the firmness of their edges, the Greeks employed words derived from the root from which came the verb glypto and so many other derivatives in current use, a root that has the sense of chiseling, of incising. That of these grooves was a glyph, and the pier with three bands was a triglyph. Nothing appeared more simple; but as soon as one casts his eye on the entablature, he cannot prevent a certain surprise. However different from each other may be the triglyphs, the front has only two large grroves; there are never three. It would then seem at the first moment better that the term diglyph would be best justified; but it has never been applied to this architectural member. One however experiences the need of understanding why the word triglyph has prevailed and how this difficulty is solved. At the side of each triglyph, it is said, where it adjoins the metope is arranged a chamfer with a width of one half of that of the two channels, of the two glyphs, properly so called. Two glyphs and two half glyphs make three, and the count is correct.

However correct is this addition, we ask ourselves if truly by it, it is proper to explain the term that embarrasses us. Doubtless there are but two channels cut in the front of the peer; but the flats enclosing them are necessarily three in number. Perhaps this trait particularly struck the mind of the spectator. Of the two elements forming the technical expression, the second indicates the procedure by which the effect is obtained, and the first alludes to the t triple enclosure.

If we find nothing on this subject in what has been transmitted by Vitruvius, of the doctrine of the Greek architects and believing the same Vitruvius, they had sought to render to themselves an account of the origin of the motive. Behind the stone or marble, they perceived more or less vaguely the beams of the ancient wooden temples, and they saw beams presenting their ends on the exterior, when the construction had just been completed, just as the saw had left it. The aspect of the ends of all those beams would have been unpleasinm;[1] they were not ignorant that one would imagine concealing them under the covering plates of stone or wood, a and that in this last case, this plate was composed of slabs that the painter was charged to decorate. A blue color mixed with melted wax increased the effect of the grooves that a accompany the joint of each slab. No arrangement of that k kind must appear in view in the edifices of the classical age; but it is curious that by conjecture those theorists came to conceive for those ends of beams a more of decoration very similar to that white distinguished the alabaster frieze found at Tiryns, that frieze which we have restored and placed in the entablature of the Mycenaean palace.[2] After all it is possible that the architects in the 5 th century had still retained some remembrance of the modes of c construction and of decoration, that we have described in regard to the edifices of the primitive age; the tradition of these procedures can be preserved in places on the buildings of small dimensions, in which the clay and wood still played the chief parts.

Note 1.p.476. Vitruvius. IV, 2, 2.

Note 2.p.476. Histoire de l'Art. Vol. VI. Pls.XI, XII, XIII

If Vitruvius did not seek to give a reason for the name

borne by the triglyph, he did not seem to have asked hemself why the ornament devoted to that member of the frieze has almost always been the channel, the triangular groove. There have been subtle and more or less ingenious conjectures made on this subject, that can be spared. The triglyph is channeled like the column because like that it is an ascending form or support, and this fluting serves to diveesify the frieze without breaking the unity, to cbeate there by its regular recurrence a rhythm that pleases the eye. Between the smooth surface of the architrave and the field cut at equal intervals by these grooves, there is sought and desired a contrast, which emphasizes still more the blue color ordinarily assigned to the triglyph.

At least on the edifices where Doric architecture arrived at its perfection, why have not the channels of the triglyph the same section in plan as the flutes of the shaft? One believes that the reason of that difference can be divined. On the column the flutes are hollowed in plans increasingly distant from the eye; each of them gives a different shadow, and the softness of the curves lends itself marvellously to outline those shadows, whose gradual decrease renders more sensible and at the same time more firm the special form of the shaft. The frieze extends entirely in a vertical plane; it is further placed higher and more distant from the spectator than even the top of the column; so that the design of the ornament there may have all its value, it is necessary to depend on the drawing; it is essential to place there lines of shadow that would be more distinct and free, thus intersecting at half a right angle the vertical and horizontal planes.

The panels separating the triglyphs are called metopes. The etymology of the word is very clear; it is formed of meta, between, and ope, opening through which one sees; but what is more difficult to know is, what idea was attached to this term by the first, who first designated thus this member of the Doric frieze. Vitruvius gives an explanation of this word, that raises more than one difficulty.[1] According to him by ope was meant the holes arranged in masonry to receive the beams, on the ends of which was nailed the plank of the triglyph. The space comprised between those

holes prepared for the beams did not long remain open. They were closed as soon as the construction was completed, and that raised and finished should rather be in the view of t the workmen, who created the nomenclature and their technical language. It would then seem more natural for designating these intervals, had they adopted such a word as metadoche, between beams, a composition of which we know no e example.

Note 1.p.479. Vitruvius. IV, 2-4.

Yet men have tried to explain and to render admissible t the hypothesis of Vitruvius. Assume an edifice in which the ceiling beams do not form the external plan of the architrave, while the spaces between those beams are filled by masonry that accords with that plan. These would not be opai in the proper sense of the word, i.e., openings passing through the masonry and allowing one to look through; but ne would have there at least rectangular cavities, that before the placing of the planks destined to form the triglyphs, would have remained open on the external face of the wall, and the space comprised between two of these holes would indeed be a metope in the sense intended by Vitruvius, literally "between holes." This explanation is the only one that gives a plausible explanation of the text of Vitruvius, and is ingenious but forced; it implies a purely temporary condition of the edifice, that can last only a few days or weeks.

Note 1.p.480. Hittorf in Les antiquities inedites de l'Attique. 1839. Note on p. 40, 41.

The best is perhaps not to seek in metope anything more than a simple doublet of a word well known in the current language, metoton. The metoton is the part of the face that extends from the root of the nose between the eyes and above them; it is what we term the front. Now like our word front, the Greek word metoton is frequently employed in a metaphorical sense to designate a facade of a building, for example, one side of a pyramid.[2] The form metope would also have had at first the same general sense of front, of a uniform and smooth surface; but usage, which never has to give a reason for its acts, took possession of it to assign to it a special purpose; it had applied it more particularly to the panels filling the intervals left between the triglyphs.

Note 2.p.480. In the contract drawn up for the execution of the works of the arsenal of Zea at the Piraeus, metoton designates a separate jamb 2 ft. wide on the facade, that stands between two doorways. (Line 23 of the text). See Choisy, Etudes sur l'architecture grecque, premiere etude; l'arsenal du Piree. Paris. 1883.

It has been admitted sometimes, that in edifices which preceded the temples of the classical age, those intervals were not closed, which would have formed a row of windows there between the beams, whose ends were decorated by the channels of the triglyphs. To sustain this hypothesis, they depend on two verses of Euripides in his Iphegenia in Tauris. Orestes and Pylades consult together; they seek the means of entering the temple to seize the statue of Artemis and to carry it away with them:- "See, says Pylades, between the triglyphs is an opening, cannot we introduce our bodies there?"[3]

Note 3.p.480. Iphigenia. Verses 113-114. (Greek text).

Weil introduces a correction that makes the phrase clearer, but does not change the sense. (Sept tragedies d'Euripide. 1868. Paris.

These verses have been compared with those of the Orestes, in which the Phrygian slave relates that he escaped from the palace over the cedar wainscot of the apartment of the women and the Doric triglyphs (Verses 1371-1372). There the preposition hyper seems to indicate that the poet conceives the fugitive as having passed above the frieze, through openings left between the timbers of the carpentry of the roof. that is more intelligible.

With several critics, we should incline to believe in an alteration of the text; but if we take it as given in the best editions, we confess to not understanding well what arrangements the poet had in view. Assuming that those spaces were open and that Orestes passed through them, that inconvenient way would not have led him where he wished to go. He would have landed under the portico, if the temple had been peripteral, and probably in the vestibule, if it had only columns between antes. In both cases after that effort, Orestes would still have found himself outside of that sanctuary in which was enclosed behind doors of bronze, as he

says himself, the image that he proposed to carry off.[1] We do not conceive what type of real or imaginary entablature to which Euripides desires to allude; the phrase offers no satisfactory sense, except in the hypothesis of a very small temple, built on the model of what we have called the Trojan house (Figs. 167, 175, 176); now that hypothesis is contrary to the idea, that in more than one passage of the drame, the poet seeks to give of the magnificence of the sanctuary of Artemis Tauride. Then one cannot depend on this text to affirm that there were really temples on which the frieze presented the arrangement opposed to that conjecture. In whatever manner one interprets the word metope, according to t the elements composing it, it seems that it should arouse the idea of a solid between two openings, rather than that of an opening between two solids. Further, assume any frieze pierced by these openings; would there not have been as many breaches through which the rain, driven by the wind, would have penetrated into the interior of the structure, to attack the wooden timbers and prepare their destruction?

Note 1.p.481. Iphigenia. Verses 99-100.

As for the stone temple, however far one goes back in its history with edifices in which he follows the development, the space between the triglyphs is always closed by a filling in some manner or another. Finally, here is what renders improbable the hypothesis in question. Neither the triglyphs, that men have desired to regard as the ends of stone beams, not the metopes pass through the frieze anywhere; behind the stone bearing the channles of the triglyphs, as behind that where the field of the metope offees itself to the chisel of the sculptor, there is another stone of nearly the same dimensions (Pl. XXXIII, 3). On that one of its faces toward the interior of the portico, the frieze presents none of t the divisions that it shows on the exterior. On that side it is composed of a continuous series of blocks crowned by a simplified cornice. These blocks themselves form a third and some times one half the total thickness. One frequently finds them in contact with the backs of the triglyphs and metopes; but they are separated, where the edifice is of g great dimensions, by an interval filled by only rougned stones, and all parts of that masonry are connected together

and to the cornice by cramps. One sees what a compact character is presented by an entirety so created; if at a certain epoch the frieze had been pierced by symmetrical openings reserved between the triglyphs, would one not find in the construction some memorial or trace of that arrangement? Now in even the most ancient edifices, there is no longer even the slightest vestige of them; the entablature forms a real and solid wall over the columns, whose unity is interrupted by no opening (Fig. 236). It is said that these openings in which ne refuse to believe may have had a reason for existence; on the stone temple, they would have rendered the entablature lighter by so much. Nearly all the burden of the roof would thus have rested on the triglyphs, by means of which the pressure would be transmitted to the architraves. The facts do not accord with that theory; this is verified by not limiting the inquiry to one or two edifices, which are too frequently taken as types. Doubtless t the block in which the triglyph is cut sometimes occupied the entire width of the architrave; but that is exceptional. In most edifices, especially in the 5 th century, the triglyph only corresponds to half that width, the other half being occupied by superposed courses. The condition of the triglyph is then the same as that of the metope; behind it, whether thick or thin, there is always a wall.

In certain temples of Sicily and in the Attic temples of the 5 th century, the metopes are slabs of marble, that at right and left are inserted at the ends in grooves made for that purpose in the sides of the triglyphs (Pl. XXXIII, 10). One would be tempted then to suppose that these slabs succeeded planks, that were themselves applied later to close a hole; but he would be greatly mistaken by imagining to find everywhere the arrangement ro interpreted. He would scarcely find it except where it was or should be ornamented by sculptures. The form of the slab and its small thickness f facilitated the labor. The marble slab was easily handled. The statuary made the decoration on it in high or middle relief; then he delivered it to the mason. He merely had to drop it into the grooves that awaited it; but the number of edifices is very restricted, where the figures project on the metope and give it a character of a scene. Where that

ornamentation is lacking, the arrangement is not that just described.

Properly speaking, the metopes and triglyphs then form t true walls, and the cornice rests on the metopes as much as on the triglyphs; also the joints of the cornice fall indifferently on the metopes and the triglyphs. This division i into metopes and triglyphs further not appearing on the internal surface of the frieze, it must be recognized that all the elements composing it almost equally with the wall behind them, aid in sustaining the part of the entablature surmounting them.

If in the edifices, from the point of view of construction there are differences in cutting and setting sufficiently marked between the blocks of tufa or of marble, that have the function of metopes, these also present a certain diversity in the appearance presented in elevation. In many temples these are bare panels, that seem to have been ordinarily painted red. (Pl. XXXVI D). There is reason to believe that frequently the brush was not satisfied to apply this uniform tone on the stone, but had traced there ornaments and figures; yet nothing remains of that decoration in color It is other wise where the architect appealed to the sculptor and left to him the field of all or a part of the metope but according to the edifices, that ornamentation was applied in a very unequal manner. There are temples where the m metopes of the frieze of the portico have remained smooth, while figures were carved only on those of the pronaos and opisthodome of the cella beneath the portico; it is thus at temple S at Selinonte (Pl. XXXVII) and at the temple of Zeus at Olympia. More frequently the external frieze is decorated by these figures; but there again, several cases are to be distinguished, according to which in the ornamentation of that frieze a greater or lesser place has been given to the sculpture. That sometimes appears only on the metopes of t the two principal facades. (Temples C and S of Selinonte, Pl. XXXVI). Elsewhere in the vicinity of the pronaos, the figures continue above the first intercolumniations of the lateral facades; thus it seems desired to return them along t the sides, but they stop on the road; it is thus on the temple of Theseus at Athens. Only on the Parthenon are all the

metopes sculptured on the four fronts of the building.

The architect did not find at the first trial the best means of utilizing the assistance lent him by the sculptor in aiding him to extend on his frieze the image and movement of life. On temple C, one of the oldest temples of Selinonte, the method pursued is truly singular. Each relief is surrounded by smooth and strongly projecting surfaces cut in the same block; these form a frame that does not project beyond the figures executed in very high relief, which decorate the metopes (Fig. 237). These figures are then located in the recess of this panel. One divines the idea that suggested this arrangement. These groups of such constrained and awkward work, must have passed for masterpieces when executed. Those who set them in place were much occupied by protecting them from storms and weather to ensure their preservation. They succeeded; but this was at the cost of serious inconveniences. That enclosure had a very heavy appearance, and if in a certain measure, it protected the sculptures from the rain, it prevented the passage of the rays that would have modeled the forms. Imprisoned between these surfaces and under the ceiling, the figures were lighted only during a very short time, when the sun was near the horizon and struck them in front; they were bathed in shadow when the luminary was a little above the horizon or lighted the side of the temple.

One cannot delay recognizing the defects of the arrangement. As soon as art was freer and more fruitful, men dared to remove the figures from that case. Henceforth they were enclosed between the sides of the triglyphs and two plain bands, that crowning the architrave and that surmounting the triglyphs and metopes. All the parts of this frame have but a slight projection and cast only a very narrow shadow on the field of the metope. The figures then present themselves in full light, the illumination varies with the movements of the sun, and assume their full value in a "frisant" full light. (Pl. VII, D).

In the temple of Zeus at Olympia and in three of the temples of Selinonte (D, R and S), the external frieze with its triglyphs and metopes is repeated on a portion of the wall of the cella, either only on the wall that forms the

back of the pronaos, or also on that occupying the same situation in the opisthodome (Pl. XXXVII); but there for reasons previously indicated, it does not always present the s same proportions as above the portico. Thus at Paestum these metopes do not have a form approaching a square, like those of the portico; the width of the panel is there more than twice its height.

This entablature of the wall of the cell is lower on the whole, than that surmounting the colonnade; the cornice is much simplified and is without a drip; that protecting moulding would have been useless in a covered area, like that under the portico or in the interior of the temple. This f frieze is never prolonged in the peripteral temples along the longer sides of the building. On the other hand, in certain edifices belongong to the century when art shows itself wisest, the architect has sometimes placed on that surface a frieze of a different type, a continuous frieze analogous to the Ionic frieze. Instead of being subject to the rhythm of symmetrical divisions, this frieze forms a band on which extends without interruption a series of figures, and it is that frieze with neither triglyphs not metopes, that one f finds over the external face of the wall of the cella in t two of the most important monuments that Doric architecture has left us, on the temple of Theseus and on the Parthenon. When the moment comes for studying them, we shall have to show how the architect proceeded to arrange the transition between that frieze, which does not properly belong to the Doric order, and the elements enclosing it. Besides he assigns to it only a part that remains entirely secondary.

On the Parthenon as on the temple of Theseus, the two friezes of different characters occupy different positions on the monuments. The treasury of the Megarans at Olympia offers a unique example of another combination. The two friezes there alternate on the exteeior of the building. The Doric frieze with its triglyphs and metopes decorates the principal facade beneath the pediment; on the longer sides of the edifice, it is prolonged by a sculptured frieze without triglyphs.[1] What results from a comparison of the three edifices seen above is the liberty enjoyed by the Greek architect; in all his creations, he essays to do the work of an

inventor, and one of the means that he employed to merit t that praise, was to borrow discreetly some certain arrangement from a mode different from that, whose general principles he accepted. The whole was to know in this work of adaptation, how to subordinate the adventitious forms to the typical forms imposed by the system in which was conceived the entirety of the work; it was important to avoid discords

Note 1.p.490. Olympia. Tafelband I, pl. 37.

We should indicate those variations; but one finds them in a very small number of temples, while the Doric frieze with its traditional divisions is nowhere wanting in the rich series of edifices that we shall study. It is then necessary to return to this frieze to define the rules according to which the architects arrange there the triglyphs a and metopes. This distribution is not made without some embarrassment. According to Vitruvius, that would even have been sufficiently serious for him to seek in it the chief reason for the change made in the 4 th and 3 rd centuries in the habits of the architects of Greece;[1] in order to no longer have to count on that difference of placing the triglyphs and of the inclination of the columns, they commenced about this time to no longer erect any but Ionic temples. That is an error, or at least an exaggeration. The restraint was not so great as Vitruvius pretends, since Greece before Alexander built Doric temples by hundreds. If from a certain moment Ionic temples were alone in favor, that is especially because the elegance of their forms was in a better relation to the taste, which prevailed in the course of the period called Hellenistic, both in letters as in the arts; also perhaps because men were conscious of having exhausted all the combinations suited to the Doric style, and that t they no longer hoped to find new ones, that would permit r rejuvenating the known themes by varying them. It is no less true that the Doric frieze, with the alternation of the elements composing it, offers a certain complication. By the natural effect of the play of those elements, a problem is set that doubtless has nothing insoluble, but which is suited by several solutions, among which the architect is obliged to make his choice, and each of which compels him to vary the secondary dispositions of his arrangements.

Note 1.p.493.Vitruvius. IV. 3, 1-2.

See the data of this problem, The rule adopted from the beginning is, that there must be a triglyph over each column, another in the part of the frieze corresponding to the interval between two columns, and finally a triglyph at each angle of the frieze. The middle line of one of the two triglyphs considered at then found to be the prolongation of the axis of one of the supports; in the other, if this line be prolonged, it falls exactly at the middle of the intercolumniation; but it cannot be the same for the angle triglyph, whose axis does not coincide with that of the column. No difficulty at all, if starting from the principle that dominates the rest of the frieze and applying this everywhere with mechanical regularity, for the triglyph of t the angle column is retained the position that it occupies over the other columns; there would then remain a half metope at each end of the frieze. This is the solution recommended by Vitruvius, and that the Roman architects adopted; o but Grecian architects do not even seem to have thought it admissible; there exists no monument on which they had recourse to it. On each facade of the Grecian temples, the frieze is terminated by a triglyph at the angle of the building. It appeared to the architect, that on this angle at w which the eye stops, something else than a half metope was necessary as a termination. That would have been too narrow for a group of figures to find spale there, and where the sculptor did not i tervene, what a mean and poor termination would have it been, for that frieze with strong divisions merely a plain panel of narrow dimensions! How different and happier would be at that point the effect of a triglyph with its bold relief, so well accented by the contrast of the c channels cut in it and filled with shadow!

From the point of view of art, nothing would then be better justified, than the method pursued by the creators of Doric architecture; but for the triglyph to be at the angle, it was necessary to move it to the end of the facade, and thus it found itself supported on the architrave, no longer at the middle, but about only a half from the capital of t the angle column. By reason of that displacement, if one assumes all the columns equidistant, the metope next the

last triglyph would be lengthened by the entire space over which that was moved. Doubtless the Greek architect, while attaching great importance to the general symmetry of masses and of lines, did not understand it in entirely the same manner as the modern architect. In his buildings the different parts of the whole and the intervals separating them p present desired rregularities, found nearly everywhere, b but which only a minute measurement has revealed; most of the time they escape the eyes of the simple spectator. It was entirely otherwise with the irregularity resulting from moving one of the triglyphs; the next metope was thus increased by at most a third. Such great disparity was very apparent to the eye; it seems to us that it must injure the entire rhythm of the frieze. Yet men sometimes adopted it directly in certain archaic temples; yet most frequently they sought to lessen or avoid it. The different solutions given for the problem may be reduced to four[1], that are represented in the opposite sketches (Pl. XXXIX).

Note 1.p.494. 1; temple of Corinth, after Blouet, Expedition de Moree. Vol. III, pls. 77, 78. 2; temple of Poseidon at Paestum, after Labrouste, pl.I. 3; temple of Segeste, a after Hittorf, Arch. ant. Pls. 3, 4. 4; temple of Theseus, after S.uart, Antiq. of Athens, Vol. III, pl. 2.

The simplest solution is that adopted on the old temple of Corinth. There the central intercolumniation being scarcely wider than the others, the metopes are sensible equal (from A to A) except two (B, B), that are reduced at the angles. These are wider than the others; if the difference in width is not so marked as one would expect to find, this is because the intercolumniation next the angle is always narrower than the other intervals.

On the temple of Poseidon at Paestum, one proceeded more adroitly. That excess of width that was an embarrassment, was divided between the two metopes next each end of the facade. Thus two or rather those four metopes (BB, BB), are equal to each other, but are a little wider than the metopes between A and A; the inequality then becomes scarcely perceptible.

Another arrangement is happier and bolder on the temple of Segeste. The intercolumniatins are there unequal; they

are very frankly enlarged from the angles to the middle of the colonnade; but the architect did not take into account these variations, when he had to place his triglyphs in the frieze. He set them at regular intervals, without requiring himself to make the axes coincide with those of the columns or with the middles of the intercolumniations. As one sees by the lines let fall from the triglyphs on the columns, t there are two systems of axes independent of each other. B But the architect separates the frieze from the supports, and by the effect of the interposition of an intermediate member, the divergences are not apparent at the first view; to perceive them requires a warned or very experienced eye.

Finally, in the temple of Theseus we find the system that prevailed since the 5 th century. The architect there placed his triglyphs so that the distances between their axes should be equal or sensibly equal. The four middle intercolumniations being nearly equal, the axes of the triglyphs of t that part of the frieze are found to correspond to those of the supports. There remains the difficulty of the last intercolumniation (AA). The intervals between the triglyphs t there remain what they were elsewhere and the angle columns are set to correspond; therefore in spite of the moving of the last triglyph, there is no longer too much space in the frieze. The last intercolumniation is 0.87 in. less than t the adjacent one. Here the location of the columns then appears to have been subordinated to the arrangement of the triglyphs.

In the systems of the third and fourth examples, the slight differences caused by the slight inequalities of the m middle intercolumniation sometimes depend on the width of of the triglyphs and sometimes on that of the metopes, more frequently on the widths of both triglyphs and metopes. The corrections which thus become necessary modify in but a very slight measure the dimensions of the elements of the frieze; they are revealed only by minute and accurate measurements.

The cornice (geison) is the upper member of the entablature; above it is only the roof; it crowns the edifice and protects the subjacent parts from the effects of storms. On the longer sides of the temple, it supports the gutters that collect the water from the roof, on the facades it bears the

tympanum with the bands, cymas and fillets, that decorate that enclosure. What characterizes it is its corbelled arrangement, the strong projection that its entirety makes beyond the frieze.

The principal part of the cornice, that sometimes forms nearly all of it, is the facia or drip, a name due to the part that it plays in rain, one then sees the water that runs down the top of the building fall in drops from the cornice like tears. The cornice is made of a course that crowns the frieze; in front it overhangs for more that one third of its length (Pl. XXXIII, 1). On the part of that s stone that projects thus over space, the two upper and lower surfaces are not parallel; the lower surface is termed the soffit of the cornice and is inclined; it rises obliquely from the outside to the inside, an arrangement that results in opposing an insurmountable obstacle to the flow of the water, of that not arrested by passing the deep groove cut at the bottom of the vertical face of the facia, which is termed the drip. On some of the oldest temples of Sicily, the temple of Selinonte, the cornice is formed of two courses; thus it has nearly twice the normal height; we shall return to this peculiarity. At the treasury of Gela, the cornice has exceptional dimensions; but it was there entirely cut in a single course.

We have found nothing similar in Egypt; it pleases men to say so. On Egyptian buildings the parapet of the terrace h has the function of the cornice; with the beautiful curve of its ample cavetto and with the terminal band surmounting it, it plays a purely ornamental part. The climate of Greece had other requirements, where rains are frequent during a part of the year. In that country, as soon as men commenced to construct buildings for which they desired to ensure some duration, they felt the need of furnishing them with a crown, that was really suited to fulfil the function of a protection of the wall; they made the facia the principal member of the cornice. We have restored this facia in the carpentry that formed the entablature of the Mycenaean palace.[1] As for the drips, perhaps they likewise began in wooden construction; but it is more probable that it was the g gable roof placed on a stone entablature, that later led to

giving the soffit of the facia a slope easily arranged in the thickness of that course.

Note 1.p.499. Histoire de l'Art. Vol. VI. p. 715-721, Figs. 311-315.

When the constructor had passed from wood to stone, was thus occupied in rendering the cornice better fitted to fulfil its proper function, he no less with surprising fidelity retained for the lower surface of the cornice the appearance, that it presented in the primitive carpentry. Everywhere on the Doric cornice that surface presents the ornament that is called mutules.[2] The mutules have the form of tablets separated by regular intervals, as if fixed against that ground, whose slope they follow. Their width is that of the triglyph; there is one over each triglyph and another above the middle of each metope. From the underside of these tablets are detached and hang in the air small appendages, whose form is cylindrical or conical, according to the edifices. Arranged in three rows in depth, they are six in number lengthwise; there are then 18 per mutule (Pl. VII, D). The motive is similar to that already mentioned below the triglyph (Pl. XXXIII, 1); wherever found, either on the architrave or on the cornice, it is always that to which Vitruvius has given the name of drops. Having everywhere the same character and the same appearance, it necessarily has everywhere the same origin. If the drops have retained their marked places in the forms of stone construction, they owe it to the method that the workman has taken here and elsewhere, to transfer to stone the forms that were produced in the use of wood. On the cornice they represent the pins that connected together the planks destined to cover and conceal the ends of the beams.[1] Men have also sought other explanations of the genesis of the motive in question and of the vogue that it has enjoyed; but each of those theories implies gratuitous conjectures and vain subtilties.

Note 1.p.500. Histoire de l'Art. Vol. VI. Figs. 512,513.

At the top of the cornice is a crowbeak moulding, which is generally an addition; above it is a very high moulding inclined to the outside, that is called a cymatium (literally "little wave") and that owes this name to the double curvature, that it frequently presents (Pl. VII, 3, E; VIII,

Pl. XXXIII, 6). On most edifices of the 6 th century, the cymatium seems to have been of terra cotta; elsewhere it was made of a stone harder than that used for the rest of the edifice. On the pediment where that cymatium terminated the structure and was seen against the sky, it had its entire development and all its value.

On the principal facades of the temple was a double cornice, that forming a part of the entablature, properly so c called, and that forming the rake cornices of the pediment. These two enclosed the tympanum. If there had not been some analogy between the three sides of this triangular enclosure, the eye would have been perplexed. The architects had taken care to retain the facia in the in the inclined branches of that border, in that cornice belonging to the pediment, though giving it a little less height. The projection of that facia is further the same as that given to it in t the cornice proper from the frieze. On the other hand, the mutules are wanting; they are never found in that place. (Pl. VII, D). The stone entablature supported by the colonade was retained, because it succeeded without transition to the entablature of carpentry; but the pediment only appeared with the gable roof, whether of earth or of carpentry, and when this mode of covering had prevailed, one was already far from what can be called the age of wood. That had not left any model that could be copied, for the decoration of the pediment, which was unknown to it. If the architect had also desired there to become inspired by the decoration in wood, that imitation would have produced for the pediment forms very different from those that he adopted; he would have had to represent the ends of the purlins that supported the rafters of the roof (Pls. V, VI). Nothing compelled him to take this method; able to regulate according to his intention the arrangement of this part of the building, he carried the facia of the cornice along the two slopes corresponding to those of the covering. By this means and due to the projection of this cornice from the tympanum, he gave to his pediment an enclosure that drew two beautiful lines of shadow of singular firmness, that ensured an efficient protection for the art work that he can have the idea of demanding from the sculptur to fill that space.

The entirety of this pediment with its cornice presented a very happy contrast between the plane surface of the tympanum and the richness of the enclosure, on which the brush of the painter had lavished his most beautiful ornaments, eggs, frets and palmatiums. This cornice, ornamented and s sumptuous, was like a diadem placed on the brow of the noble edifice, yet enhanced its imposing majesty.(Pl.VII, 8).

That cymatium of the rake cornices of the pediment sometimes continues with the same section and the same water spouts entirely around the edifice. Also frequently it stops at the side after returning around the angle; the cymatium is then lacking on the cornices of the lateral facades.

As a general rule, the drops of the mutules were cut in the material of the blocks forming the cornice; yet on one of the treasuries of Olympia, they were all inserted; the workman set them separately in holes, where they were fixed with lead. On the temple of Poseidon at Paestum, they were set afterwards in the same manner, but doubtless with less care; their places are now only marked by holes in which t they were formerly inserted. This procedure was frequently employed to replace those broken off by accident. On more than one monument may be perceived the traces of these repairs

The great taste of the architect knew how to utilize for the decoration of the cornice, the elements intended to collect the water from the roof and to discharge it outward. On the most ancient edifices, such as the treasury of Gela, he was contented with water spouts of cylindrical form; but these spouts had a very poor appearance;(Pl. VII; Pl. XXXIII, 6; ;Fig. 238); later he had the habit of giving these spouts the form of heads of animals, most frequently the muzzle of a lion. Under the chisel of the ornamentist, these heads f frequently assumed a very beautiful character (Pl. VII,3; pl. IX; Fig. 239).[1] The mouth is widely opened, and the water runs over the pendant tongue, whose top is hollowed in the form of a channel, an artifile unseen by the eye from below. Why was the head of a lion chosen in preference to all other forms, to fulfil that function? An Egyptian fashion has been alleged, caused by astronomical considerations; it has also been stated that Greek mythology assigned to the lion the part of protector of springs.[1] Neither of these ex-

explanations seems inposed. This type had become familiar to the Greeks by frequent use made of it in oriental art, by the numerous examples of it offered to them by the objects of every kind, that they derived in various ways from Egypt, Syria and Asia Minor; what finally made it successful was especially, that it has nobility and beauty. It is related, that one time it was first devoted to that use by the Corinthian potter Boutades.[2] Whatever should be thought of this tradition, once that the motive was invented, it had sufficient success to ramain for centuries the only one in current use. While our constructors of the middle ages have given very diverse and frequently bizarre forms to the gargoyles of their edifices, the Greek architect, when he wished to lend to his an ornamental character, nearly always used only the lion's head; yet at Epidauros, the gutter of the temple of Artemis bore the head of a dog instead of the traditional lion's head. These heads were sometimes gilded. On temples where art displayed all its resouces, they were modeled with a breadth of style, that gives reason to believe that the head was designed by the master sculptors, to whome had been entrusted the execution of the figures of the pediment and of the frieze. In the same edifice, these lions' heads were not always alike, Grecian art loved so much to put invention and variety into even the least details

Note 1.p.501. The museum of Palermo possesses a very beautiful series of these water spouts in the form of a lion's head; they came from different temples, and one can there follow the development of the type, from the archaic severity to the most ancient examples to the softer and looser execution of the late time of art.

Note 1.p.502. Durm. Baukunst, p. 137-138.

Note 2.p.502. Pliny. H. N. XXXV, 15[2].

Note 1.p.503. This was noted at Metaponte. (De Luynes & Debacq. Metaponte. Folio 33. p. 42).

Where the large cymatium with its spouts no longer exists on the longer sides of the temple, the water reaching the two lateral facades, after having run down the slopes of the roof, ran off by means of the spaces separating the lower ends of the covering tiles; from the cornice they fell directly on the ground. On temple C at Selinonte, the water

seems to have run through openings of irregular form equally spaced in a beautiful cymatium of terra cotta, that separated palmatiums (Pl. VII, 2; Pla VIII). It is rarely thus. On two temples of Selinonte (B and S) the gutter continues along the longer sides and discharges through lions' heads, that regularly open in the cymatium.

In seeking to give an idea of the cornice, of its character and appearance, we have so far assumed ornaments carved on the stone or painted on its surface; but the chisel and the brush could only do their work with some precision, when they attacked either marble or limestone of very close grain Where the architect had no materials other than a porous tufa full of shells, it was necessary to cover by a coating of stucco all surfaces of the stone, which gave the monument something of the appearance of a monolith; but this covering with stucco was a very delicate and very lengthy operation. At certain points of the Greek world, another expedient was employed to remedy the insufficiency of the materials. On no part of the building was there greater need of clean lines and vivid tones than on this cornice, which is indicated by its name (corona in Latin), crowns the temple and is detached against the blue of the sky with the greater vigor, when the tones decorating it are more vivid and warmer. Terra cotta was more appropriate than any other material to serve for covering the part of the monument menaced most by storms. One scarcely has to explain that in these conditions when facings of painted claw were found in the form of fragments, in the ruins of several temples of Italy and of Sicily, the architects that colloceted them could hardly divine at first what places these facings formerly occupied in the edifice. They believed that they could not utilize them in the restorations that they presented, except in the interior of the temple as coverings of beams that supported the ceiling.[1]

Note 1.p.501. This was the case for Debacq and for Hittorf himself.

That was a hypothesis which nothing has since confirmed. The German excavations of Olympia have shown the terra cotta employed in an entirely different manner. In demolishing, not far from the treasuries, a Byzantine wall built of ant-

antique fragments, there uere found a number of wrought stones in which were recognized with entire certainty the remains of the treasury erected by the Sicilian city of Gela, and the various parts of its entablature. Among those pieces of tufa were some, whose surfaces were formerly visible and were dressed and polished with care, while elsewhere they were only roughly pointed, which permitted the inference t that in the edifices they were covered by overlays, which concealed them from view. Those facings were also found in the wall itself. These are facings of painted clay, whose form is that of long cases with only three sides. Their dimensions agree exactly with tose of the defferent cornices brought to light by the excavation; there are those of the cornice of the lateral facades and of the straight cornice, and that of the rakes of the principal facades. What completes the proof that all those pieces of terra cotta were employed to conceal the external faces of the cornices, that face merely roughed, are the round holes formed in the clay, to which correspond nails that are still seen fixed in the stone on the top of the cornice (Pl. VIII). This sort of o boxes, without that precaution, would have adhered to the member whose contour they fitted; but men feared the effects of the violence of the wind or of shocks of the ground, and for greater safety, they had recourse to this mode of fastening to prevent all displacement.[1]

Note 1.p.505. W. Dörpfeld, F. Gräber, R. Borrmann, K. Siebold. Ueber die Verwendung von Terrakotten am Geison und Dache griechischer Bauwerke. (21 st programme of the Winkelmann festival). 31 pp.+ Figs in text+ 4 plates in color.1881

Above this clay facing the architect placed a cymatium of the same material, which completed the two cornices on the facade, the horizontal and the raking cornices of the pediment. The profile of this cymatium recalls that of the Egyptian cavetto up to a certain point; but the hollow is less and is flatter (Pls. VIII and XXXIII, 6). One notes that t the gutter continues here on the horizontal cornice ar on the raking one, a very exceptional arrangement. On the cymatiums of the lateral facades, cylindrical spouts project strongly and serve as ejectors. Concealed by this cymatium, the upper angle of the facia needed no decoration; there is

painting, only on the vertical surface and on that attached to the bottom of the cornice; this soffit was also visible from below. (Pl. VII, bottom).

These verifications have been a light; they finally permit the assignment to their true places of the fragments of the same kind, that had been found in very great abundance in magna Grecian and Sicily. The principle was the same everywhere, but the arrangements varied. For example, see temple C of Selinonte, one of the edifices on which one seems to have made the most beautiful use of clay for the decoration. This covering there does not cover the entire cornice; it always covers only the upper portion. The cornice was f formed of two superposed courses.[2] There was first a cornice, whose soffit presents the peculiarity that the mutules are alternately narrow or wide, according as they correspond to the metopes or the triglyphs of the frieqe. Above in the v vertical plane are perceived traces of stucco, which proves that the stone was visible for the entire extent of this b- band. This block supported another of nearly the same section, en the top of which were made gains that received the ends of the rafters of the roof. There in what one has found of the elements of that second course, the tufa no longer has the sage appearance; it is only roughed eveeywhere; no trace of stucco. By the nature of the work, one divines that nothing of that course was visible, that its front face was concealed from view by a cymatium of terra cotta; now there have been collected from entirely around the temple numerous fragments of a beautiful cymatium of that material, whose height is the same as that of the blocks forming the second course (Pls. VII,2; VIII). Those fragments of the cymatium belonged to the sides of the temple; nothing of the cymatium of the pediment has been found; it is then impossible to k know if those two cymatiums were alike, and in case they w were different, how they joined. In these conditions we co could not think of introducing them in Fig. D of plate VII; then we have retained everywhere the crowbeak moulding, that must crown the cornice, according to Hittorf. This detail has only a very secondary importance in this general view, which was especially intended to give the idea of the character of power and of noble severity presented in the most

ancient examples by the Doric temple. Borrowed from the geometrical drawings of Hittorf, all other elements entering into that perspective were the subject of exact measurements, and leave no place for doubt.

Note 2.p.505. Dörpfeld corrects the eeror committed in t this respect by architects, who attempted to restore the t temple, and who were mistaken from not knowing all the fragments. (Ueber die Verwendung, etc. p.6).

The mode of setting here was no longer entirely the same as for the gains that extended along the entire cornice. I The stone of the upper cornice slightly receded from that of the lower course; the bottom of the clay member then rested on that projection. The covering there had only two sides, the front face on which was applied the ornamentation, and the horizontal return fitted into a groove made in the bottom of the blocks of the last course. The bronze nails that were still fixed in the tufa corresponded by the places occupied, to the holes pierced in the narrow return of the clay covering. Further, that did not stop at the cymatium; it was continued by the gutter, above which also extended a running motive, that by its large openings produced the impression of a series of tile fronts. Still all that was in a single piece, the gutter, its return, the palmatiums and the lotus flowers surmounting it, moulded in the same slab of clay (Pl. VII, 2). This terminal member projected strongly from the rest of the entablature; thus the soffit was ornamented by a fret, like the cornice of the treasury of gela. The entirety of that decoration gives a high idea of the skill of the ceramists, that the architect took as collaborators, so as to supplement the inefficiency of the materials at his disposal.

If for these artisans was required a singular skill for fashioning pieces of such complicated arrangement and also of great dimensions, at the same time they made proof of great taste in tracing their profiles and their ornamental motives, as well as in the choice of the tones by means of which they accented the reliefs and the designs of their mouldings. Those tones and motives will be studied elsewhere with the entirety of polychrome ornamentation. Further, it does not appear that the habit of employing terra cotta

was thus general in the Grecian world; it seems to have remained peculiar to certain regions, to those where the materials supplied by the quarry were least beautiful. In Magna Grecia and in Sicily were those facings most used. If some treasuries at Olympia had cornices so covered, this peculiaritn in their decoration is explained by the fact that cities like Gela and Metaponte, when they constructed their chapels in Elis, remained faithful to the traditions of their local architecture. There have not yet been found in the Peloponessus, even where the stone was only a very coarse tufa,[1] remains that appear to belong to pieces of that kind. Yet the antefixas of the Heraion suffice to prove that very early, the potters of that country were sufficiently advanced in the practice of their art to be able to furnish to the architect coverings of this sort, if he pleased to require them.

Note 1.p.507. Dörpfeld, etc. Ueber die verme etc. P.11,12.

In any case, it is difficult to refuse to see in the use of these facings an indirect confirmation of the observations, that ue presented on the subject of the transition from wood construction to stone construction.

When one examines the remains of edifices whose material is a more or less porous tufa, he ascertains that two different methods were taken to conceal the defects of the stone to create smooth surfaces on which was developed the ornamental designs. Nearly eveeywhere in Greece, the limestone was coated with a fine and tenacious stucco, impermeable to rain and well suited to receive the work of the brush, Besides, on the other side of the Adriatic while using stucco, men also employed slabs of clay on the upper part of the entablature, to cover the facia and to form the cymatium above it.

Let us consider the coat of painting applied on the stucco especially on the upper parts of the edifice; does one not have reason to see there a memory of what in more ancient edifices would have been extended to the wood to protect it and vary its appearance? Further, we have found at Tiryns and at Mycenae coatings of lime on which color was applied, laid on the walls of crude bricks or of rubble. Thus also from structures of that kind may have been borrowed this

method of stucco, that was applied to stone of poor quality on many temples.

The second of the procedures that we have described belongs more nearly to construction in wood; it recalls it in a clearer and more direct fashion. The panels of glazed terra cotta were fixed on the stone by nails; now nails are not made for stone; they can find place only in holes drilled with the point, and also then do not render their the same services as when they are driven toto the elastic fibres of oax or beech. Then where anciently one had been accustomed to nail on wood the facings of metal or of clay, he could continue to employ nails thus when stone is substituted for wood in the entablatore; it could be nothing but a survival, the effect of a habit contracted in a time when wood formed the entire body of the monument. To pierce the wood and sink it it were originally forged the nails, that on the cornices of Selinonte and of Gela attached to the bands of the tufa the slabs of terra cotta, decorated b: vivid colors, which the architect, even when he no longer built except in stone, continued to demand from the potters, whose aid had been so useful to his predecessors, to those who had to derive from the adjacent forest all the elements of their edifices.

Note 1.p.508. This what has been very well indicated by Dörpfeld (Ueber die verm. etc. Pl. 12).

10. Roughing and Hoisting Stones. Joining Stones.

In the entablatures are members that lie over the spaces in different ways; such are the architraves, that are loaded by a great part of the height of the roof and span the intervals of the intercolumniations; such are also the cornices that make a strong projection from the face of the frieze. It is unnecessary to form a single body from all these pieces, which have different forms and functions; it is essential to establish a connection between them, which makes all solid, and that defies all the effects of shocks in the ground frequently affected by earthquakes. Cut stones being always set dry, men provided for that need by the use of mechanical connections, dowels of wood or of metal that connected in a vertical plane two drums or the beds of two courses, cramps of bronze or of iron, which in the horizontal plane joined together the blocks and held them in place (Pl. XL).[1]

In many cases the wall can omit these cramps; men indeed abstained from their use when building the ramparts of cities. The thickness of the mass sufficed to ensure its solidity. It was not the same in the temple. The walls were thin and high; more precautions were required to ensure their stability; together with the columns, they aided in supporting t the roof. In these conditions it was impossible for the architect not to employ the same methods in all parts of the edifice, to hold together all the elements of construction. Taken in its entirety, the temple is further a work of art, that of its creations in which Geeek art has held in honor to giving more care in even the least details. Then we cannot be surprised to meet with these fastenings everywhere, from the stylobate to the cymatium one finds them in the w walls of all cellas.

Note 1.p.509. 1; pl. XL, 1, column of temple R at Selinonte. Hittorf. Pls. 42, 43. 2; column of temple of Zeus at Olympia. Olympia, pl. XIII, 2. 3; column of theple of Poseidon at Paestum, Labrouste, pl. V, B, F. 4; fastening at Olympia, treasureis of Selinonte. Olympia. Pl. 37. 5, 6; different forms of cramps. 7; entablature at Eleusis. Antiq. of Attica. Chap. V, Pl. 4. 8; Entablature of Rhamnus, same. pl. 5. 9; upper part of entablature of treasury of Megara. Olympia, pl. 38. 10; the cramp fixed there in the hole. 11; temple R of Selinonte; cornice. Hittorf, pl. LIV, 4. 12; lower courses of the wall of the Heraion, means employed for obtaining close joints. 13; temple C at Selinonte. Inserted d drop. Hittorf, pl. 24. 14; wall of opisthodome of temple R of Selinonte. Hittorf. Pl. 44. 15; architraves of temple of Nemesis at Rhamnus. Antiq. Ined. Chap. VI, pl. 8. 16; architrave from Egina. Garnier, pl. 17. 17, 18; wall of treasury of Syracuse. Olympia, pl. 34. 19; cramp at Z. 20; triglyphs of treasury of Gela. Olympia, pl. 40. 21; walls of treasury of Sicyon. Olympia, pl. 27.

Wooden dowels were employed in some temples to connect together certain parts of the entablature; but they rendered service particularly between the drums in the erection of the columns. Inserted at the centres of those drums and in square holes, prisms of hard wood to connect the drums in pairs. These dowels were very well protected from dampness

by the .ccurate adhesion of the surfaces of the drums; they are sometimes found nearly intact only in edifices of the 5 th century. Further, in the temples of the 6 th century, the dimensions of the holes cut at the middle of the drums permit no doubt to remain concerning the use of wooden dowels. These holes were generally square, as in temple R at Selinonte (Pl. XL, 1); round ones are also found, for example in a shaft of the lower order to the temple of Poseidon at Paestum (Pl. XL, 3).[1]

Note 1.p.510. Hittorf & Zanth. Recueil des monuments de Segest et de Selinonte, p. 515.

In parts of the edifice other than columns, metal was employed in preference to wood. Bronze and iron alone lent themselves to an arrangement, which must have been adopted very early on all workyards; they alone support without injury the contact of melted lead, which men had the abit of pouring into the holes for fixing. Lead had the double advantage of being fusible at a very low temperature and of r resisting oxidation. Poured while fluid into the cavities in which had already been placed the dowels or cramps, it entirely filled them; it fitted those fastenings, that it thus protected from all chance of moving; at the same time it enclosed them in a covering, that sheltered them from r rust. By wooden dowels were connected the drums of columns of the temple of Zeus at Olympia (Pl. XL, 2);[2] but for greater precaution, the workmen always introduced there metal pins in some places. In the section opposite, see the lower joint; it was intended to reinforce it, and between the two drums near the centre of the shaft was arranged a space that permitted the enclosing of the pin by a lead cap, a mode of fixing, of which examples are also found in other parts of these edifices (Pl. XL, 3).

Note 2.p.510. Olympia. Textband II, p. 6.

These dowels doubtless rendered a very appreciable service by the intimate union that they established between the beds of courses vertically;;thus they give to a wall a consistency that approaches that of a monolith. It is further in the horizontal plane that these fastenings are most necessary in the absence of all mortar; thus the mason has multiplied them most there. Very close together and set in different

ways to prevent displacements, which without them might be produced between the materials only juxtaposed. This is made especially apparent by a perspective view of the entablature of a treasury at Olympia (Pl. XL, 9), and the plans of the architraves of Rhamnus and of Egina (Pl. XL, 15, 16). There are cramps of all sorts. The simplest and most frequently employed have the form of an I (Pl. XL, 17), others that of an H (Pl. XL, 10), and still others that of a Z (Pl. XL,19) or of an N (Pl. XL, 20). Champs are also made of a wide band of metal with its ends turned down to fit into holes sunk in two adjacent stones; one would call it a handle (Pl. XL,4,5,(

Iron has been by far most frequently devoted to this purpose; it alone was employed by the mason in most edifices of Sicily, at Olympia and in all the temples of Athens. Bronze cramps are only found exceptionally at Samothrace, Epidauros and sometimes in Sicily.[1] The Acropolis of Athens has furnished fragments of edifices built of tufa, where the fastenings have been entirely executed with lead alone;[2] but it was n not possible for that practice to find many imitators; lead is too soft to establish a very firm connection between the stones. On the con.rary, it could suffice when it was only necessary to fasten light covering pieces on which no pressure was exerted. Drops were very often fastened thus; a n narrow channel was cut in the stone where they were to be attached, and that was continued to the drop; this was set in place, and the melted metal was poured into the hole ((Pl. XXX, 13).

Note 1.p.513. Durm. Baukunst. p. 79-81.

Note 2.p.513. The same.

The custom of employing these fastenings must have extended in the 6 th century among the workmen who labored everywhere in building temples. There is no trace of them at t the Heraion of Olympia, in what remains of the wall of the cella. By an artifice in cutting there, the constroctor sought to obtain a close adherence in the end joints between the blocks of limestone forming the substructure of its walls of crude bricks. Slightly relieved at the middle, the surfaces only touch at their edges; they touch each other like two lips pressed against each other (Pl. XL, 12).

Even when the use of fastenings was everywhere employed,

men continued to have recourse to certain special ways of cutting stones, at least for the parts of the temple whose equilibrium was least stable. One can judge of it by the cornice of temple R at Selinonte (Pl. XL, 11); in the stones composing the entire cornice, a projecting tenon was reserved at a joint, that corresponds to a recess of the same s shape sunk in the opposite joint. By that jointing, they n hoped to prevent all lateral displacement of the elements of the cornice; but what skilful and costly work was imposed to obtain this result! There also is emphasized the idea evidenced by the complication and multiplication of the fastenings with iron and lead; men have the firm intention to spare nothing to ensure the duration and integrity of the noble edifice, which serves as a habitation for the protecting gods of the city.

These conscientious scruples are no less marked in the w work of roughing, which is done on the workyard before setting it in place, work that we can follow in all its phases by observations made on numerous edifices, that by a series of various circumstances have never been finished. The principle that inspired the constructor is easily seized; he i desired to avoid at any cost, that the stones cut by him s should risk receiving any injury in the course of the construction, that might damage them, causing cavities on either surfaces or edges, which it would not be possible to remedy except by repairs, always awkward and precarious. The means of preventing these accidents was to retain everywhere an excess of material during the entire duration of the preliminary operations, that would fall only at the time of the final dressing. These systematic procedures of roughing can nowhere be better studied than in the temple of Segeste; t the edifice remained in the roughest state (Fig. 130).

See at first the column, seen in section and perspective (Pl. XLI, 1, 2). At the four corners are seen prisms, nearly rectangular, that border the edges. Those prisms were not ornaments intended to remain after the work was finished; there is nothing similar on any Doric capital; those appendages are protections, intended to protect the angles of the capital, exposed to strokes that might have broken them, i during the duration of the work. The blocks composing the

architraves afford opportunity for the same remarks concerning the fillets beside the joints (Pl. XLI,3). These fillets form a border everywhere that the blocks must first come in contact and that circumstance clearly indicates their character; they have been reserved to prevent two sharp edges from being damaged by striking each other when the surfaces of the joints are set together. These fillets no longer remain on the architrave except next the cella; they had already been removed on the exterior when the work was interrupted, never to be resumed. The same methods have been applied to the blocks of very regular masonry, of which the stylobate is built. The bosses there occupy the middle portion of the surfaces and served to protect them from wear; as for the knob that projects on the front of the stone, this is nothing but a projection that serves for hoisting and handling the stone. All these bosses and knobs must disappear under the same tool, when the edifice received the final t treatment. A narrow chisel draft all around the joints indicates the plane to which must later be brought the surface.

Note 1.p.514. Pl. XLI, 1; section; 2, elevation, of a column of the temple of Segeste. After the geometrical drawing of Hittorf.Pl. 4. 3, architrave of the same temple, after Hittorf. 4; column of temple of Nemesis at Rhamnus. Ant. ined Chap. VI, pl. 10. 5; fragment of a Doric shaft found at Olympia. Olympia. Pl. 35. 6; course of temple S at Selinonte, after Hittorf. Pl. 57. 7; courses of propyleion at Athens. 8; application of stucco on a column of Paestum.

At temple S of Selinonte is a little different arrangement, a mode of cutting that does not emphasize the care of making the vertical joints correspond with the sinking.(Pl. XLI, 6). It is scarcely necessary to add that they remain faithful to these practices in the constroction of the marble edifices of the 5 th century, where the care for perfection was carried farther than in the tufa temples of Sicily; this is s seen in the substitruetuture of the propyleion at Athens (Pl. XLI, 7). With their symmetrical arrangement these projecting panels do not displease the eye; it finds them on a number of edifices not entirely completed; it will become accustomed to them so well, that it will not fail to find some pleasure in the contrast between the rough surface of the boss

and the polished one of the directing chisel draft. Thus on many buildings of the Hellenistic epoch, these preparatory cuttings have become the final ones; what was merely an expedient has changed into an ornamental motive.

It is with columns as with entablatures and walls; whether monolithic or composed of several drums, they were cut with smooth shafts in the portico, the pronaos or the cella. On the temple of Segeste, they have all remained in that f first state, that in the mind of the architect could only be a temporary condition. Grecian art never conceived the Doric column without the luxury of flutes; but what risks would it not have run, if the shaft had already been completed when there still had to be hoisted the blocgs intended for the entablature, and the movable scaffolds were erected against the facades and then removed! The fillets and annulets could be cut without inconvenience on the Workyard before setting; they were sheltered when the support was once on foot, by the strong projection of the capital; but the body of the column could not count on the same protection; it would have been difficult to avoid injuries to those sharp edges, that in the Doric order extend between the parallel channecs. This work of cutting the flutes was then r reserved for the end of the undertaking; but at least when marble formed the material of the edifice, the foreman of the workyard was not satisfied with rounding his column; he started it, as one would san for a work of tapestry. He fixed the number of flutes and drew their curves; then he executed them for a short distance at the top drum on which rested the capital and just at the bottom of the one resting on the stylobate (Pl. XLI, 4); one even finds these sometimes cut entirely around the sinking formed in the slab of the stylobate on which rests the lower drum. When the erection was once completed, the moment came to finish and dress the edifice, the workman only had to follow these very precise indications, to connect together the two very narrow bands crossed by the flutes.

At Segeste is is not as at Rhamnus, as on the temple of Demeter at Eleusis, or that of Apollo at Delos; the flutes are not started beneath the columns and at the foot of the shaft. This is because the execution on temples of tufa

does not permit such minute care. The flutes were cut at o once on the tufa, and then on the drum thus diminished was laid a coat of stucco sometiess 0.32 to 0.39 in. thick. In modeling this coating, the tool easily gave to the edges t the neatness and vigor that could not have been obtained w without difficulty in a coarse grained stone. Fig. 8 of Pl. XLI represents a shaft at Paestum half covered on a coating of stucco, of which only a few remains exist today in those ruins.

At the upper parts of the building commenced the general dressing. From the cornices one descended to the frieze and the architrave, then to the capitals; the flutes were then chiseled on the shafts of the columns. A drum found at Olympia teaches us how that operation was executed (Pl. XLI, 5). On a part of the circumference, the flutes are only indicated on straight planes. When these planes were cut on the entire circumference of the drum, making this a polygonal solid with as many sides as it must have vertical channels later. Here the drums at the time when the work was suspended, was ready to pass from the second to the third state. On a part of that surface the flutes are already cut in the concave curve characterizing them. In the great temples, t the architraves, triglyphs, drums and also other parts, represented considerable weights. How did the Greeks undertake to erect those heavy blocks, and in a general way to raise and set in place the stones composing their edifice? The s stones themselves inform us on this subject; many of them still bear the marks of the tools by means of which the workmen formerly handled them. One must have alreadn noted on several architectural members that we have reproduced, besides the holes that received the cramps are other holes not drilled for that purpose, and that could only serve for hoisting the stones (Pl. XL, 9, 20). Pl. XLII is intended[1] to show the various procedures employed for this purpose.

Note 1.p.519. Pl. XLII. 1; loop. 2; temple of Egina. Capital of the upper order of the cella. Garnier, pl. 17. 3; f fragment found on the Acropolis of Athens. 4; plan of the drum of a column of an Ionic column from Lesbos. 5; cornice of a treasury at Olympia. Durm, Fig.83. 6; architrave of the internal irder of the cella at Egina, after Garnier, pl. 17.

7; cornice of temple of Egina, after Garnier, pl. 17. 8, 9; substructure of cella of heraion of Olympia, and section of one course, after Durm, Fig. 63. 10; tongs. 11; course showing how the tongs takes hold of the stone. 12; entablature of temple of the Giants, after Cockerell. 13; courses of the propyleion at Athens. 14; stylobate of temple of Segeste. Hittorf, Pl. 5. 15; triglyph of temple of Concord at Agrigente, Durm, Fig. 63. 16; lewis. 17; architrave of temple R, Hittorf, pl. 47. 18; cornice of temple A, Hittorf, Pl. 16.

The simplest procedure was to place ropes around the stone to be raised, whether this was one of the drums of the column, or an entirely different element of construction, one of the stones of the wall; but so that while being hoisted, the stone should not risk becoming detached. There were left after roughing , prismatic projections, by which one might succeed in firmly fastening the rope. (Pl. XLII, 3, 13, 14). Still even with the aid of these projections, it was not impossible for this rope to slip sometimes on the block; then methods were sought to prevent all chance of accident, and several were found. That which seems to have been most frequently employed consisted in the use of what our masons call the loop (Pl. XLII, 1). A groove with two orifices is cut like a hole for a seton, in the block to be handled. It is in the form of a U or sometimes in a horseshoe;;its openings are quite near each other on a surface invisible in the construction (Pl. XLII, 2, 4, 6, 8, 9, 12, 15). The end of a rope is passed through it and knotted. Thus being traversed and held in this loop, the stone cannot escape that hold unless the rope breaks.

The same system was employed in a slightly different manner, when the sides of the stone must remain visible, for example on the capitals. Two holes are pierced in the abacus that join to form a canal. The solid portion left between the ends of the hole serves to hold the rope (Pl. XLII, 2). Elsewhere it is made similar for hoisting a block of the architrave. (Pl. XLII, 6). The groove there has a little different form, but the procedure is the same.

In the cornice of a temple of Selinonte the groove for the rope is carried twice entirely around the tail of one of the blocks of the cornice (Fig. 240).

Vitruvius mentions iron tongs with points fitting into

holes made in the stone. One can represent that tool (Pl. XLII, 10) and take into account the manner in which it held the blocks by means of holes made in their sides (Pl. XLII, 11); but so far as we know, no fragments of architectore h have been found in the ruins of edifices, that bear the marks of the tool in question. It is not the same with another mode of suspension, very ingenious but more complex, that obtained by means of the tool known in our workyards under the name of lewis. This is a metal appliance composed of t two or three pieces, that together are wider at bottom than top; they are placed separately in a hole of the same shape sunk in the stone; once fixed in place, they are held more strongly as the block is heavier. The lewis may have a single or double dovetail; we have represented it in its more developed form (Pl. XLII, 16). It is further proved that this type was known to Greek constructors; in the cornice of temple A at Selinonte, the holes in which these wedges were inserted have sides of equal inclination.(Pl. XLII,18). Also with the lewis were raised in the same city the architraves of the temple.(Pl. XLII, 17). The part of the lewis projecting above the top of the stone, as with us must have a ring to which is attached the rope.

All these arrangements designed to allow one to seize and handle the blocks are evidence of the use of a series of q quite different machines; some of them with much less power, must very strongly resemble those used by our constructors. "Thus the use of the lewis simplifying hoisting by ropesl assumes sets of pulleys fixed either to special masts or to the scaffolds, and the magnitude of the masses moved by the ancients authorizes the thought, that these pullies were u used in a manner to increase the effect while slowing the movement. Elsewhere the texts are formal; we find the principle of the pulleys explained in the theoretical works of the Greeks,[1] and Vitruvius in the first century B.C. indicated in his treatise the derrick with windlass or wheel, the various sorts of pulleys adapted to it, the combinations of derricks and capstans, shears, etc., the whole with such c clearness and precision, that in perusing the first chapters of his tenth book, one would believe that he was reading a modern treatise on hoisting machines.[2] It is useless to des-

to describe apparatus, that we daily see in action on our workyards."[3]

Note 1.p.523.Aristotle. Mechanics. XIX.

Note 2.p.523. Vitruvius. X, 1,5.

Note 3.p.523. Choisy. L'art de batir chez les Romains. p. 117-118. For more details on those machines, see Hittorf. Arch. Ant. VIII. Chap. IV, 1.

Men have sometimes believed that the architects made frequent use of inclined planes on which they hauled or pushed the blocks till they reached their places to be set; but t the study of the monuments does not confirm that hypothesis. There is indeed scarcely an edifice, where on examining the stones entering into its structore, we do not find either the projections or the holes that we have describbed; as a attested by both, these blocks were raised by the aid of r ropes; Pliny is the only one that mentions the inclined plane; this is with reference to an edifice of colossal dimensions, the temple of Artemis at Ephesus, where the column was about 59 ft. high.[1] It is possible that the machines w which usually corresponded to all needs, were unsuited to lift to such a height the loads that they had to raise; to relieve that embarrassment, they built there against the p portico one of those ramps with gentle inclination, to which Egypt seems to have had recourse sometimes, when it erected its gigantic pylons;[2] but this an exceptional case that the two architects of the temple, Thersiphron and Metagenes, t there resumed the method whose character was entirely primitive and barbaric. They had to struggle against very peculiar difficulties; we learn from Vitruvius that to bring f from the quarry to the site of the work the drums of their columns and the architraves of their entablatures, it was necessary for them to invent apparatus of entirely special arrangement, considering the enormeuss weight of those blocks

Note 1.p.524. Pliny. H. N. XXXVI. 21, 95.

Note 2.p.524. Histoire de l'Art. Vol. I, p. 524-525.

Note 3.p.524. Vitruvius. X. 5.

11. Ceilings of the Portico and Cella.

We have demonstrated that in the peripteral temple, the wall of the cella and the external colonnade were independent of each other, at least in principle; but to create an edifice which had its visible unity, if was necessary to c

cover the void space separating those two parts of the whole, and to establish a certain connection between them. What f formed this connection was the ceiling of the portico and the double slopes of the roof. It is proper to first define the composition of the ceilings; we shall then determine that of the roof, with its carpentry and covering.

The ceiling of the portico and that of the front and rear pronaos had at the origin as the principal elements, beams perpendicular to the walls and leaving rectangular spaces between them (Pl. V, Fig. 1); one end was built into the e entablature of the portico and the other rested on the wall of the cella. In the great temple at Paestum are still seen, cut in the cornice course, rectangular recesses that received one end of the ceiling beams. These holes, according to the accurate measurements of the architect who has best studied this monument,[1] are indicated in our pls. V and VI. In our pl. V will be perceived the openings marked inside the portico, at the height of the bottom of the frieze, along the entire length of one of the lateral facades; they will be distinguished still better, because they are seen in front at the same height on the back of the triangular wall forming the pediment of the opisthodome. Further, the beams have already taken in the recesses the places reserved for them (Pl. V, Fig. 1); another drawing represents a more advanced stage of the work; one sees there an open ceiling, a sort of lattice that constitutes the elementary skeleton of the coffers.

Note 1.p.525. Labrouste. Temples de Paestum. Pls. IV, V, VI, VII, VIII.

In the primitive peripteral temple, such as we know it by the Heraion of Olympia, the entire ceiling, beams and coffers, was certainly made of wood. On the other hand, in the temples of the 5 th century, these coffers and beams are of marble; but even them, in the arraggement of the members w whose combination forms this covering, one recognizes the forms and arrangement suited to wood, which could have originated only from carpentry. The stone beams are faithful copies of oak beams, and in the panels which close and finish the spaces left between them, one recognizes not to be mistaken the imitation of a work in carpentry (Pl. VII, Figs

5, 6). In the wooden ceilings, by means of beams joined at right angles was covered the spaces between the main beams (pl. VII, Fig. 3). These spaces were divided into square p panels, that formed superposed frames, recessed one above the other. These panels we term coffers or cassions. The upper part of each coffer is terminated by a slab entirely c covering it (pl. VII, Fig. 4). When the constructor substituted stone for wood in that part of the edifice, he docilely reproduced all the features of the models that he had u under his eyes; thus the architect, when he undertakes today to restore these ceilings, can at pleasure require from either the material for covering his portico. Thus in his beautiful restoration of the temple of Paestum, Labrouste has accepted the hypothesis of a stone ceiling, while other architects and we ourselves have believed it necessary to suppose all that covering executed with carpentry. Yet the principles that we have used are just those employed by our predecessor, and thaces that wall has retained of the insertion of the beams, that formerly sustained the entire arrangement of the coffers.

If we have adopted here this system, as we had taken it in the case when we had to restore some one of the old temples of Sicily, this is because those stone coffers are in place neither at Paestum nor in any edifice in question, a and that further no more at Selinonte that at Paestum, one has found the least fragment among the rubbish of all kinds that covers the ground around the monuments. The proof is certainly negative; but it no less has a great value. It further results from the plan drawn by Labrouste, or rather from that imposed on him by the gains cut in the entablatore, that certain stone beams which he restored were badly suited to the habits and requirements of stone construction. That is notably observed for the two beams on the principal facade opposite the second and fifth columns, that are directed toward the antes of the pronaos. They do not seek their support on the entablature of the pronaos; they intersect the beams of the side portico where it covers the space, an arrangement very well explained with a halved timber, b but which one can no longer understand with the use of stone (pl. VI, Fig. 1).

Fig. 3 of plate VII presents the entirety of that arrangement of the restored ceiling of Paestum, and Fig. 4 gives its details. The form of the spaces to be covered being given, the properties of the material and the methods that it suggests to the workmen, the coffees reestablish as of themselves, just as they are here arranged. Their details are given in Fig. 4 at a larger scale, but only in a rough state, as necessary here for a conjectural restoration. In this edifice the gains into which entered the ends of the ceiling beams have an opening of 1.38 × 2.76 ft. It is to be assumed that those beams were composed of two superposed blocks each 1.38 × 1.38 ft. The cabling that divides into two equal parts the marble beams of the temple of Theseus is perhaps only a survival of that arrangement presented by the wooden beams in the ceilings of ancient temples (Pl. VII, Fig. 6). It will be only in Attica, we believe, that in the 5 th century men had begun in the ceilings to replace wood by marble. When the temple of Egina was restored, men did not hesitate to restore there the beams and coffers of stone or marble; yet the ruins do not offer the least vestige of these elements (pl. XLIII).[1] The temple of Theseus is the most ancient edifice that possesses a marble ceiling; but it suffices to study our plates VI and VII to be convinced that the change in material has caused no change in the forms. Plate VI, Fig. 2, shows the framework of the beams and coffers, such as the spectator would see them if placed above the building; the same ceilings appear in plate VII just as you would see them from beneath, by raising the eyes when walking under the portico. Figs. 5 and 6 represent a part of the ceiling and the marble coffers of the temple of Theseus; one would have no difficulty to recover there the characteristic arrangements of the wooden ceiling that we have restored according to assumed principles in the temple of Paestum.

Note 1.p.527. Garnier. Le temple de Jupiter Panhellenios a Egine. 1884, p. 32.

One will notice the very narrow rebates by which are connected the planes superposed in these coffers. Everything leads one to believe, that even in the most ancient temples, color served to increase the effect of these mouldings.

Executed in carpentry in the earliest edifices, the later with each feature translated into marble, this type of covering is that which one will find in all temples of the archaic period, if theyhave retained their ceilings. In the temple of Nemesis at Rhamnus (Fig. 241), and in the temple of Theseus (Fig. 242), this system of beams and of coffers prevails nearly the same everywhere, over the vestibules a and the entire portico, i.e., entirely around the temple. One does not know temples in which the ceilings of the front and rear pronaos are not arranged on this plan; but there are some in which the arrangement varies from the two pronaos to the portico; over the latter are no beams separated by coffers, but a simple slab, in which are cut panels in the form of coffers. It is thus on the Parthenon (Fig. 243) and at Bassae (Fig. 244 and Pl. VII, Fig. 7). There is a s simplification that is explained by the change in material, but which allows to be clearly discerned the imitation of wooden ceilings.

If one considers the height of the floor of an edifice, that is arranged in three different planes, it is easy to understand that it should be the same for the ceilings.

The pronaos and the posticum have a little greater height than the portico, and a little less than the cella. The ceiling of the portico is again sufficiently well preserved in several temples; in some places are some remains of that of the pronaos; but as for the ceiling of the cella, nothing remains in any Greek temple, neither in place nor even in the state of ruins found among the rubbish of ruined edifices. One cannot cite an architectural fragment to which may be attributed this purpose, from its form and its decoration.

Whether the interior was narrow or broad, the ceilings of all cellas must have been built of wood; they presented very simple arrangements, which with more richness in the decoration, must be analogous to those of the ceilings of the portico (Pl. VI, Fig. 2). This was a variation of the mode of construction called by extension. All this wood offered a ready prey to fire; there are scarcely any rather celebrated Grecian temples, which we do not know were burned several times.

Of the entire span in the temples that had no internal c

colonnades, in the others the ceiling was divided into three longitudinal parts corresponding to the three aisles of the temple. That of the middle must have been the most sumptuously decorated; the beams might be enclosed within thin facings of terra cotta or of metal, inlaying them in bronze, gold and ivory; but it is probable that men were most freq„uenlty contented to trace with the brush varied ornaments on the surfaces of the beams, as well as on the ground of the frames of the coffers. With the regularity of its symmetrical compartments, its luxurious ornamentation, the ceiling thus formed a sort of ample and rich horizontal tapestry interposed between the spectator and the roof of the edifice, that concealed from the eyes the carpentry that it supported.

12. Carpentry of the Roof.

If in the stone ceilings of more than one temple, one has faithful copies of the wooden ceilings that preceded them, no temple has retained its roof. The principal element of that was a framework that formed a system independent of t the carpentry of the ceilings, with which it had no point of contact.

This carpentry of the roof has disappeared everywhere; b but it has also left on the walls of certain edifices traces, that permit its restoration. For example, this is the case for the temple of Poseidon at Paestum, that by its state of preservation represents today better than any other the type of temples with internal colonnades. Above holes that mark the places of the supports of the ceiling, one sees at one place on the inclined courses that form the copings of the pediment of the cella, the rectangular holes that received one end of the purlines and ridge, and on the other hand, on the sides at the top of the entablatures are holes in which were inserted the rafters. According to the dimensions of these gains and the positions that they occupy, one measures the dimensions and divines the arrangement of the principal elements of the roof. By the aid of this data are restored one of these frameworks with almost entire certainty, which does not differ much from those of other edifices of the same kind. We shall describe it as presented by our restoration (Pl. VI, Fig. 3, and Figs. 245, 246).

There is not to be sought a number of members correspond-

composing our carpentry, even the least complicated, principals, kingpost, tiebeam and struts. The carpentry of Paestum consists of purlins, a ridge and rafters; to these members are added over the cella, beams or false tiebeams, which have the function of supporting the ridge. Two arrangements are to be distinguished in this carpentry. At the two ends before and behind the cella, the purlins and ridge extended from wall to wall (Fig. 245). In these parts of the edifice, these elements alone with the rafters compose the carpentry; but this very simple system was no longer applicable to the portion of the roof that rose over the cella. Above its two secondary aisles, rafters sufficed to cover the narrow space between the two walls; but it would have been impossible to find a ridge beam sufficiently long to span the interval represented by the length of the central aisle. This ridge must then be composed of several timbers, that must be supported below the joints by means of cross beams resting on the small walls placed above the second s story of the internal order (Fig. 246). Purlins and false tiebeams form the resisting framework of the carpentry,the skeleton on which extend the rafters. Those are divided into three series on each slope. The first extends from the ridge to the little wall built over the internal columns, the second from the wall of the cella to the highest course of the entablature. Regarded in its constroction, this roof allows to be recognized all the elements of the carpentry, which in the primitive age must support the terrace of the great megaron (Figs. 177, 178). The system is scarcely modified by the conditions that imposed the establishment of a roof with two slightly inclined slopes.

Long after the end of the archaic period, the Greek constructor continued to use this system, which is of extreme simplicity; in effect, its principle is that of the arrangement of the roof of the arsenal, that the celebrated architect Philo built at the Piraeus between the years 346 and 328. There are only insignificant differences between the carpentry restored at Paestum, by calling the monument as evidence of its ancient state, and that restored from the arsenal of Philo from the very precise indications of the inscription containing the specifications of the works.[1]

Here are the remarks on this point by the learned engineer to whom is due this last restoration; they apply just as w well to both of the two corresponding works:- "Nothing is simpler than this construction; but nothing differs more c completely from what is practised today. Among us the tie-beam is essentially a member subject to tension, a tie. H Here the tiebeam appears as a supporting member, and there is no trace of the idea of a truss, i.e., of a combining in which the weight of the roof is resolved into a tensile stress; this fundamental idea did not present itself to the mind of the constructor. The entire roof is only a series of timbers resting on each other, whose weights act vertically without ever being converted into tensions; on the whole, that marks a very primitive phase in the history of the art of carpentry."

Note 1.p.533. A. Choisy. Etudes epigraphiques sur l'architecture grecque. 1884. Premiere etude; L'arsenal do Piree, according to the specifications of the works, p. 21.

Here the beams had to oppose flexure; to not yield, it w was necessary for them to be of great dimensions, and the width of the gains permits the statement that the purlins satisfied that condition.[2] They were not all of the same size. The dimensions varied from 2.0 to 2.36 ft. Those were great timbers; but still these dimensions were not exceptional and beyond customary ones. In the carpentry of the arsenal of the Piraeus, the same purlins were 2.53 × 2.33 ft.

As for the rafters and judging from the gains made for t them, they had dimensions of 8.66 × 8.66 ins. The spaces b between them were 21.65 ins. The tiles extended from rafter to rafter. Thus they were about 26.38 ins. wide. Were battens interposed between them and the rafters? One of the best arranged existed in the roof of the arsenal of the Piraeus. There the battens were covered by a layer or coatinm on which were directly placed the tiles, that also had the advantage of preventing the heating of the carpentry.[3] This information is given to us for the building of Philo. In the temple of Paestum the stone has retained traces only of the principal members of the carpentry, of those with one end supported on the wall.

Note 2.p.533. Labrouste. Temples de Paestum. Pl. IV. Sec-

Section on A B. Actual condition.

Note 3.p.533. Choisy. Etudes epigraphiques. p. 22.

The system whose principle we have explained must have b been employed with slight modifications required by the dimensions of the edifice, in all the temples, as in the enclosure of Olympia at the Heraion and the temple of Zeus, where were as many points of support as at Paestum; but in temples in which the internal order was wanting and as in certain temples in Sicily, where the cella attained widths of 32.8 to 36.0 ft., the problem was no longer suited by the same solution. The constructor must have solved it by erecting a truss; but according to all appearance, this truss was a very simple arrangement. A skilful artisan, if he properly selects his timbers and frames them with a certain precaution, can design carpentry of great span, without kingpost or struts, with two principals and a tiebeam. There are no other timbers in the carpentry on which rests the roof of the cathedral of messina, and yet at the base of the triangle the aisle is 45.9 ft. wide.[1] It is the same in the cathedral of Monreale, where the width is 46.9 ft. in the clear. (Fig. 247). Perhaps it is necessary to see in the type of truss applied to these buildingu a legacy from the past, t the effect of habit and of local traditions. These procedures go back even to architects contemporaries of Empedocles; they transmitted them to their successors, and their practices came from generation to generation until the masters, who built for the Norman princes so many beautiful edifices in the 11 th century of our era.

Note 1.p.534. Charpente de la cathedrale de Messine, drawn by Moret. Pl. III. GE41. A certain role was reserved for metal in the mode of attachement of the timbers of this carpentry; perhaps the ancients did as much.

In the 7 th and 6 th centuries, tiles properly composed the roofing of temples. Byzes of Naxos, it is said, in the first half of the 6 th century gave the example of sawing into form of tiles the coarse-grained marble, that nas supplied by the quarries of his native city.[2] On the other hand, there were found on the Acropolis of Athens marble slabs, that seemed to have performed the part of an edifice preceding the Median wars, an edifice to which also belonged a

cornice of the same material, some fragments of which remain;[1] but the products of this industry, special at Naxos, at that epoch had only been utilized in that island, in the neighboring island and the cities like Athens, which maintained close relations with the Cyclades. In Attica itself that practice only became general in the 5 th century, that men adopted the habit of substituting marble for terra cotta in the covering of the temple; one would be quite naturally led to that when the temple was built of Pentelican marble. Then everywhere shone the whiteness of the crystalline stone from the ridge of the edifice to the widest step of the substructure. Until that time, clay had been devoted to that use, clay that lent itself so well by its low cost and by the facility it offers to moulding; men will long remain contented with it, perhaps always. Yet it seems that where marble is wanting, men sometimes employed in a spirit of e emulation slabs of stone instead of tiles;[2] but this has o only been an exception there, the covering of marble or stone was only a copy of the covering in tiles, that was itself born with the peripteral temple, and whose arrangement was continued from the beginning in a manner to guarantee an effective protection to the sanctuary, the vestibules a and the portico, over which extended the shelter of its inclined terraces.

Note 2.p.534. Pausanias. V. 10, 3.

Note 1.p.535. Lepsius. Griechische Marmorstudien. p. 125. The fragments of the cornice to which we allude are those, a specimen of which is given in the Antike Denkmäler. Vol. I, pl. 50, Fig. E.

Note 2.p.535. Hittorf found in the ruins of temple S of Selinonte slabs of stone, that had all the appearance of tiles. (Arch. ant. etc. p. 560).

The principal element of this covering is flat tiles with borders, which rest on the rafters, either directly or by the mediation of battens (Pl. XLIV, 3, 4, 14; Pl. XLV, A, B, C, D).[3] Very heavy, they could remain in place by their own weight; also sometimes to fasten them better still, they would be fixed to the rafters by nails. In the direction of the slope of the roof, these tiles were so placed that the lower edges of those in the second row covered the top edges of those of the first row, and so on up to the ridge. The

water ran down that inclined surface; but there were joints in the direction of the slope by which the rain might have pene.rated the roof, if they had not been covered by tiles[1] of a special form. (Pl. XLIV, 1, 2, 10, 11). These were most frequently round, or at least we find them shaped thus on the most ancient edifices, such as the Heraion, treasury of Gela, temple C of Selinonte (pl. VII, 1, 2); they are also found triangular, for example on the temple of Egina (PL. VII, 7), at Metaponte and at Selinonte, where they are elegantly decorated on their upper surfaces and their sides. (Pl. XLV).

Note 3.p.535. On the different forms presented by these tiles and their different arrangements, according to the t time and the country, see the obseevations of Gräber in the Programme often cited, Ueber die verwendung von Terrakotten im Geison und Dache griechischer Bauwerke, p. 14-22.

Note 1.p.536. Pl. XLIV. 1; 1, 2, 3, 4, temple R at Selinonte. 1, 2, covering tile seen from below and above; 3, 4, flat tile seen from above and below. After Hittorf, pl. 46. 5; elevation of ridge tiles found at Selinonte. 6; longitudinal section of the same tile. 7; transverse section of r ridge tile. 8; side view of same tile. 9; perspective view of the same tile. Notizie degli scavi, 1884. Pl. VI. 10; cover tile with knob viewed from beneath. 11; cross section of same tile. Type of Greece proper. Gräber, Ueb. die verw. p. 18. 12; temple R, perspective profile of cymatium of a pediment. 13; perspective of assemblage of these tiles seen from the reara After Hittorf. pl. 46. 14; Selinonte. Flat tile, perspective of underside. Notizie. 1884, pl. 6. 15; Temple of Apollo at Bassae. Assemblage of ridge tiles, of cover tiles and of the cymatium of the pediment, seen from the rear. 16; section of the assemblage of the cymatium. 17; section and assemblage of tiles. 18; plan of these tiles. 19; plan of ridge tile, after Blouet, Exp. de Moree, II, pl.8

Note 2.p.536. On the very old temple of Tiryns, of which only very few remains have been found, the antefixas being triangular, the covering tiles must present the same arrangement. (Schliemann and Dörpfeld, Tirynthe, p. 276, Fig. 125, tuiles ornees).

The ridge tiles are also covering tiles; they have the f

form of half cylinders, beneath which penetrate in pairs the upper edges of the last row of tiles, on each slope(Pl. XLIV, 5,6,7,8,9,10). What distinguishes them is, that they most frequently have a projecting ornament, whose repetition forms a crest that is outlined against the skn. This ornament is ordinarily a sort of plamatium (Pl. VII, 1).

Along the openings of the pediment is always a row of tiles that present a quite peculiar arrangement (Pl. VII, 1). These tiles rise almost vertically at their outer edges and their relief furnishes the cornice with its cymatium, the crown of the cornice. Behind this projection, the tile is concave; it is hollowed into a gutter, that ends at the spout arranged at the two ends of the facade (Pl. XLIV, 12,13, 14,15,16). In certain temples (S and R of Selinonte), the gutter appears to have extended entirely around the edifice. On others, the long sides have a gutter that does not exactly reproduce that of the pediment, or indeed they have no gutter at all. The Parthenon is in this case. Then the top of the cornice serves to support the antefixas; thus is termed in imitation of Roman architects the slab of terra cotta in which terminates the lower ends of the lowest covering tiles (Pl. VIII, 2). Whether they are of clay or marble, these antefixas form a secondary crest parallel to that of the ridge. The eye of the spectator stops on that line and on its symmetrical cut-outs; that limits the planes of the edifice by its elegant and firm outline.

Nowhere is the happy effect that must be produced by this border, more sensible than in a restoration of the cornice of temple C of Selinonte, such as can be reestablished by recent researches, that have revealed the importance of the part that terra cotta played in the edifices of Sicily (Pl. II; Pl. VIII). On a bent slab of terra cotta, a sort of gutter perforated in its decorated face, rested the lower ends of the tiles. The water from the roof escaped by certain openings of irregular form but symmetrically spaced, that even determined the ornamental motives. As we have already indicated, the cornice proper must there be surmounted by a course that constituted a second facia, an upper facia, where the stone was further completely concealed by a rich facing of terra cotta. With the cymatium and palmatiums that

terminated it, the latter formed a polychrome decoration of the most beautiful character.

The Greek constructor has then made proof of marvellous ingenuity in the composition of his roof; he has spared nothing that this roof of tiles should fulfil a twofold purpose, serving both as a protection and an ornament to the building on which he placed it. This end was attained at t the first time. The roofing of the Heraion must have been much simpler and plainer in appearance than that of the temples of Sicily. Thus the flat tiles placed on the rafters had no tuned-up edges. They were slightly concave (Pl. XLV, A, P). The remainder of the system was doubtless pleasing, less complicated and less ornate than in the roofings, of which we have given restorations. Having once entered that path, the progress due to the skill of the artists, that m modeled, and burned the colored clays, could not fail to be very rapid. No other architect has created monuments whose covering may be a work of art in all the force of the term, or while opposing an impassable barrier to leaks of the v water, has so efficiently contributed to the effect and the expression of the edifice.

What no less aided in giving to the roof that beautiful character was the use, that the architect made of the antefixas and acroterias. The antefixas are the appendages in which terminate the last tiles of a row, those next to space. (Pl. VII, 2; Pl. XLV, treasury of Megara).[1] Rising vertically, these appendages accompany and thus extend the ascending lines of the edifice; in the oldest edifices they are bordered either by a triangular outline (Pl. XLV, Tiryns), or by rounded forms in the later, that are sometimes limited by a continuous curve (Pl. XLV, Egina),[1] sometimes by the wavy lines of scrolls and the symmetrical branches of a tall palmatium (Pl. XLV, 2, Egina). The last type has an elegance entirely different from the preceding; it lends itself to much more varied arrangements. One of the happiest is that presented on one of the longer sides by the cymatium of temple C of Selinonte (Pl. VII, 2); a row of lotus flowers alternately upright and inverted above or below a palmatium, there forms the row of antefixas. On other tiles that seem to have belonged to the cresting of the roof, the simpler

lotus flower is outlined by a slight relief (Pl. XLV., temple C).

Note 1.p.540. Antefixa from an ancient Dorci temple at Tiryns. Schliemann. Tirynthe. Fig. 123. Ridge tile at templeC. Hittorf. pl. 25. Treasury of Megara at Olympia. Olympia, pl. 37. Egina, antefixa seen in front and back. Terra cotta. B Blouet, I, pl. 54. Egina, another antefixae of marble. Same work. Decorated tiles. Metaponte. De Luynes & Debacq. Pl. 8. Temple R. Hittorf. Pl. 48.

Properly speaking, the antefixas are only the projecting borders of the extreme covering tiles. On the contrary, the acroterias are independent pieces of large dimensions, that are placed after the erection of the rood, on the apex of the angles of the roof. (Pl. VII,A,B,C). They were of terra cottawhere the roof was made of tiles, of marble where marble slabs formed the covering. The acroterias played a useful part in the constroction. Set in places where the materials were particularly exposed to sliding, they prevented that danger by their weight,even,where sufficient provision had not been made for the adherence and solidity of the masonry by the special cutting of the joints by the strength or number of the cramps. At the same time they contributed very usefully to the effect of the whole. By their relief they attracted attention to the points where met the principal lines of the edifice; without intersecting those lines or affecting the harmony, they occupied the angles and raised the pediment. Thus they elevated and animated the roof by diversifying its appearance.

Clay at first served to furnish the elements of this decoration. The most ancient acroteria known is the great piece of painted terra cotta, that surmounted the pediment of the Heraion of Olympia; it has been possible to put together t the numerous fragments found in the excavations, and to restore it almost entirely. It had the form of an enormous disk 7.4 ft. in diameter; this disk fitted the apex of the pediment by an opening corresponding to the inclination of the pediment; we show it in elevation and section to make intelligible the arrangement, by means of which they succeeded in fabricating it without deformation, and in fixing it solidly on the ridge of the roof (Pl. XLVI).[1] The motives that

ornament the surface are nearly all borrowed from the repertory of the geometrical style; one can even say that all are. It has even been believed that leaves are recognized in the fourth row from the centre; but the forms to whice it is p proposed to give that name offer nonly a very distant analogy to those characterzing the plant kingdoma What this decoration especially recalls by the concentric zones into whit is divided, and from which extend and stop the different motives, are certain disks of clay or of metal, that passed under our eyes, when we were studying the art in which we saw the contribution of the Dorian tribes (Figs. 17, 55, 77, 73). The designs were first stamped with very prominent hollows and reliefs in the moist clay; then color accented the lines. On a ground of blackish brown, the motives are detached in white or in red approaching violet.

Note 1.p.543. Pl. XLVI. The acroteria of the Heraion, elevation and section. Bötticher. Olympia, pl. 17. A, B; tiles of the Heraion. Gräber. Pl. 16. C, D; covering tiles, Sicilian types. The same, pl. 17. Acroteria of a pediment of painted marble. Ant. Denk. Vol. I, pl. 50. Another acroteria of the same material and taken from the same edifice. Same.

If the constroction of such a great slab of clay is evidence of rare technical skill in the potter, the general form of the piece is heavy; the design and the scale of tones remain very poor there. Then this work,must be dated from the 7 th centoury at latest. With the two other acroterias represented on the same plate, one feels himself in presence of a far more advanced art. Found in the excavations on the A Acropolis of Athens, they are both of Pentelican marble; they come from the crown of the same edifice, which was p probably built about the end of the 6 th century by Pisistratus on his sons, and according to the dimensions of the fragments collected, must have been about 49.2 ft. long by 36.0 ft. wide.[1] The two parts reproduced here formed portions of the inclined cyma of a pediment,,which is explained by the small dimensions of this moulding; they terminated it below at the angles of the tympanum; it is assumed that the largest of the two belonged to the pediment of the principal facade, and the other to that of the rear facade. The entire arrangement is here happier in effect than at the

Heraion; there is truly elegance in the movement of this ample volute, that is rounded above the gutter and projects so boldly into space. It is the same with the ornamental motives that decorate the cymatium and the volute; if on it are only chevrons and checkers that remain within the principles of purely linear design, on the cymatium the open f flower of the lotus alternates with the palmatium. The red and blue colors are lively and gay.

Note 1.p.544. Wiegand in Antike denkmäler. I. p. 39.

In spite of the differences already mentioned, the marble disks of the acroterias of the Acropolis again recall the clay disk of the Heraion; but on the temple of Egina, that seems to date from the first years of the 5 th century, the architect has already taken an entirely different method f for these members. Already for some time, he had called on the figure to fill the surfaces of the pediment and of the metopes; what was more natural than to use it also to decorate the angles of the roof? According to some remains that have been recovered, it has been possible to restore the acroteria, which surmounted the pediment at Egina. Executed in the same marble as the statues of that pediment, it consisted of two female figures, erect and draped, between whom rose a palmatium of beautiful design, where broad volutes were scrolled in contrary curves. Behind, the palmatium was supported by a rampant lion (Pl. VII, A, B). At the two angles of the tympanum the motive was simpler, but of the same kind; a winged griffin rose above the lion's head, that formed a spout at the end of the gutter (Pl. VII, C). The acroterias will henceforth be more or less similar to those just described; by the choice of the theme they belong to the art of the statuary; it will then be from the sculptor charged with the ornamentation of the temple, that the architect w will require them on all edifices of some importance.

13. Mouldings.

In its most ancient monuments, Doric architectore rarely employs to model and diveesify the vertical surfaces of its edifices, other elements than rectangular mouldings in the form of fillets, whose importance varies according as they have more or less relief and height. Besides these, it does not really possess but a single moulding of curved section

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and blue colors are lively and gay.

Note 1.p.344. Elegant in Antike Denkmäler. I. 1. 39.

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13. Mouldings.

In its most ancient monuments, Doric architecture rarely
employs to model and diversify the vertical surfaces of i
edifices, other elements than rectangular mouldings in th
form of fillets, whose importance varies according as the
have more or less relief and height. Besides these, it do
not really possess but a single moulding of curved sectio

peculiar to it; we speak of that moulding termed crowbeak, that always surmounts the facia of the cornice (Pl. XXXIII, 2). In the 5 th century that moulding also appeared under the portico in the profile of the ante (Pl. XXII, 5, Fig. 232).

The crowbeak, fillets and astragals may occupy different places on the edifice. It is not the same with the cymatium By its dimensions, that is the most is the most important of all mouldings comprised in Doric forms. We have already indicated the effect; we have shown how it sometimes exists only on the facade, while at others it extends entirely around the edifice. Whatever method the architect adopted in this matter, what defines it is that modeled at first in c clay and later cut in stone, it always forms the terminal part of the entablature, the crown of the cornice. The curves that outline its profile vary from one edifice to anoth er. On the treasury of Gela and on the temple of Metaponte, the cymatiums were of terra cotta. On the first of those ed ifices, the profile of the cymatium forms a flat hollow; it approaches what we term the cavetto (Pl. VIII); at Metapont below a square fillet is a quarter round formed by a small curve to a vertical facia from which is detached the lion's head serving for the discharge of water (Pl. IX). There is the same diversity on edifices where the cymatium is made of stone, like the rest of the building. At Egina the cymatium has the form of a very flat reverse ogee. On the templ of Zeus at Olympia, we find two quarter rounds that join an thus form two collars, at the Parthenon is a flattened quar ter round, at Bassae an ogee, etc.

During the first time of its development, Doric architect ure does not seem to have known mouldings carved with the chisel; it had recourse to painting, when it desired to giv some richness to the appearance of its mouldings. Thus at the temple of Egina. In terra cotta were certain ornaments first executed in relief; one sees eggs and beads appear in the facings of Metaponte (Pl. IX) and the beads in a cymatium of Selinonte, that must be of nearly the same time.[1] T These beads and eggs are rarely seen carved in stone before the middle of the 5 th century. The oldest example that can becited is apparently that furnished by the temple of Cada-

Cadacchio in the island of Corcyra. That edifice is now destroyed and has not been entirely uncovered; only some elements of it have been determined, but which present a very peculiar character, and that allow a very distant date to be assigned to the monument.[2] There are on the cornice eggs as well as two astragals with beads and disks (Figs. 248, 249); but these ornaments there have neither entirely the same form nor the same proportion as on the temples of the 5 th century. The beads are much larger there with relation to the eggs, and than they will be later; the eggs themselves are narrower and more elongated. The ornamentist is then in the period of essays and experiments. For example, see this motive of eggs superposed on the pearl bead, a motive that one will frequently see reappear in the decoration of the edifices of the succeeding age. The artist has already invented and composed their entirety, but he has not known yet how to coordinate the elements and to find for each of them the most elegant and happy form.

Note 1.p.548. Dörpfeld. Ueber die verw. etc. Pl. II, 3.

Note 2.p.548. What remains of this temple has been described and drawn by W. Railton in Antiquities of Athens and o other places in Greece and Sicily. Vol. VI, Pl. IV, Figs.4,5.

Such simple mouldings of the most ancient Doric architecture donot seem to have suffered the direct influence of a foreign art; it is possible that certain secondary forms, such as eggs and beads, may have been suggested by oriental models; yet in Egypt and Assyria they have an outline sensibly differing from that, which they have taken under the chisel of the Grecian ornamentist. In the same order of ideas, there are also to be mentioned rare monuments on which the profile of a crowning moulding recalls that of the Egyptian cavetto. This is recognized on two fragments of painted terra cotta facings contained in the musesms of Palermo and of Syracuse;[1] The same as.ragal surmounted by an ample cavetto; but in these fragments of Sicilian cornices, there is below the astragal a facia projecting at the bottom, an arrangement found in Egypt only in the band terminating all edifices. The members where one believes may be perceived this influence of an exotic type are further of small dimensions. This same form reappears with the astragal and the

terminal fillet, perhaps yet more characteristic, on the c crown of the little s.ructure discovered at Selinonte (Fig. 250); but the cavetto there has only a very weak developme-nt. On the contrary, it describes a beautiful curve on an Attic funerary stele, which must date from the end of the 6 th century (Fig. 251). There if the as.ragal is lacking and if it is replaced by a light triple fillet, the cabling that decorates the hollow of the cavetto reproduces one of the special peculiarities of the Egyptian moulding, and the wide band that surmounts the whole adds to the resemblance. It is difficult to see in this the effect of a simple chance; one would rather be tempted to explain it by a mode of direct imitation. The artist charged with cutting that tombstone would have had under his eyes one of those little objects made in Egypt or copied from Egyptian types, that P Phoenician commerce distributed in Greece, objects that repeated, whilh simplifying and reducing them, the motives t that on the banks of the Nile had been created by the greater arts for the ornamentation of great religious and civil edifices. Without servilely copying its model, the entirety of the form had been borrowed from that.

Note 1.p.549. Dörpfeld. Ueber die verw. etc. Pl. II, 5, 6.

One may be astonished that the example so given was not followed more frequently. By the bold hollow of its outline, this form marvellously suited the ornamented stele. Projecting outside with the high band terminating it, the upper p part of the slab played the part of a sort of hood adapted to protect from storms the image painted or carved beneath it on the rectangular panel; within the shadow, it emphasized by contrast that image presented in full light; finally, it also had the advantage of presenting to the eye something of the appearance of a capital and of its robust vigor.

14. General Proportions of Doric Temples.

Men have frequently attempted to prove that in Grecian a architecture the proportions were determined by some sort of general constructions.

Whatever may be said, the proportions of a good number of temples correspond imperfectly to the drawings, that have been imagined.[1]

Note 1.p.551. This kind of operations have a value only

if their results are verified by calculation. Drawings at small scale, even if carefully executed and apparently very accurate, almost always lead to erroneous solutions.

General Proportions of Plans.

We have already drawn at the same scale the plans of the principal temples (Pls. XIV, XV, XVI, XVII, XVIII). One can thus obtain a clear idea of the extreme diversity of their dimensions.

We now desire to make apparent the differences in their proportions. On the other hand, for that it is necessary f for us to draw those plans at different scales, but taking care rigorously to give them the same width. In the parallel that we are to establish, this constant width will be taken between the axes of the lines of columns along the sides of the temples. The capital importance of these axes in tracing the proportions, in plan as well as in elevation, sufficiently justifies our choice.

There it is now understood, and we shall not repeat this explanation, that in all the diagrams of plates A, B and C (XLVII, XLVIII, XLIX), the dimensions in width are related to the lines that we have just indicated.[1]

Note 1.p.552. Consequently the lengths are comprised between the axes of the columns on the front and rear facades.

In Table A are the perimeters of all temples of which we have been able to procure accurate measurements. Each rectangle is constructed from a single measurement. In no case have we established a mean between the different measurements given by the architects that have measured the same temple.

All these rectangles have been reduced to the same width A B and arranged in the order of the extent of their length. By this means it is easy to see at the first glance the differences in proportions that distinguish them.[2]

Note 2.p.552. See Note on p. 569.

Now let us consider the base A B. (Pl. XLVII, 1). If on that base we superpose three squares having sides A B, we shall at once observe that the smallest temple of the series that we have formed slightly exceeds the lower side of the third square (2), and that the temple with the largest proportions has not quite reached the upper side of the same

square (27). Those figures then represent the extreme limits between which the lengths of the temples were comprised during the entire duration of Grecian architecture.

Table A affords opportunity for other observations. A Greek temple can have both great dimensions and small proportions. The converse proposition is equally true. This remark may surprise persons that freely confuse these two terms; our two diagrams will aid them to understand how they differ. For example, let us consider the temple of the Giants at Agrigente, which is truly a giant among temples; it has more than 328 ft. of length and more than 53,820 sq. ft. of area. (XLVII, 6). In spite of such enormous dimensions, this edifice has small proportions, while other temples with a length less than 98 ft. and an area of 3,230 sq. ft. have greater proportions than that colossal monument (7, 8).

This diagram also shows that the temples with a hypostyle cella do not show any similarity of relations between them. Among these edifices are some of small, average and great proportions, for example the temple of Egina (6), the temple of Zeus at Olympia (16), and the Heraion within the same enclosure (25). Temple R at Selinonte, that attains in Table A the largest proportions, has a cell without columns (27).

After this let us arrange a chronological series of the proportions just recognized, in the upper diagram of Table B. (Pl. XLVIII). The constant width of the temples is A B. As for the relations existing between the dimensions of t these edifices, they are expressed in figures and are graphically indicated by parallel lines or ordinates.

The movement of the lines joining the upper ends of those lines shows that the proportions are not developed in any regular order, and exhibits their fluctuations in the course of the time.

Another diagram on the lower part of plate B relates to the dimensions of width and length of temples, likewise in the order of time.[1] In the last the variations produced by the lengths of the ordinates differ considerably from those of the upper diagram. Comparisons are thus easily established; the contrast is much more marked between the differences of dimensions than between the proportions.

Note 1.p.555. The figures are given in metres of 3.28 ft.

In brief, the laws resulting from the tables just analyzed are those having as results the dissimilarity of proportions in all the plans of temples, and their irregular succession in the course of time.

These being recognized, there should no longer be a question of connecting these plans of the same type of outline; but could one in each case determine the perimeter by a special construction? Nothing absolutely proves that it may not have been so.

It indeed results from a theorem of M. Hermite, that two lengths taken at random may be connected by a great number of geometrical constructions of simple character. One conceives that in such conditions it may be difficult, if not impossible, to recognize those employed by the Greeks.[1]

Note 1.p.556. Also consult on this subject the researches of Lejeune-Dirichlet. Werke, vol. I, p. 634.

However, research in this sort of outlines is not deprived of all utility; it sometimes attracts attention to peculiarities, that otherwise might remain unperceived. We present below some constructions of this kind, that we believe are unpublished. Fig. 252, 1 represents the plan of the temple of Qeus at Olympia. Half the diagonal of the base is transferred to a point on one side of the perimeter. By a parallel to the base the length so obtained is transferred to the other diagonal at 2. This point is the centre of an arc, which by its intersection with the horizontal axis of the plan, fixes the position of a secondary square equal to that of the base, and determines the length of the sides of the edifices with an error of about 1.18 ins. for a length of 202.44 ft.

A slightly different drawing is applied to the temple of concord at Agrigente (Fig. 252, 11). The transverse axis of the temple is obtained by the arc with centre at the point 2. The error is 0.79 in. for a length of 124.2 ft.

For the temple of Corinth (Fig. 252,iii), the operation is very elementary. It suffices to let fall on the longitudinal axis of the plan a diagonal of the square of the base to find the transverse axis. For a length of 169.2 ft., the error does not reach 0.79 in.

The temple of concord is again represented in Fig. 252,iv).

A drawing different from that in Fig. 252,ii, and so easily intelligible as to require no explanation, gives the length of the sides to .0079 in.

Without executing as we have done, our operations on the surfaces of the plans themselves, we can obtain results as accurate by another kind of drawings. Fig. 252, v represents the perimeter of the Parthenon. If one constructs on the 1 line 1 A′the two dotted squares, and prolongs both ways the diagonal common to these two figures, it will suffice on t the one hand to extend outside the diagonal of the little square to determine the point A, and on the other hand to project the centre of that little square on A′. 2 to obtain the point B by means of a transfer with 2 taken as centre. A B is the length of the temple, and the error is less than 1.18 ins.[1]

Note 1.p.557. We have drawn the perimeter of the Parthenon according to the measurements of Iwanoff (Architektonischen Studien, Part I, pl. 22. Berlin).

Whatever their degree of accuracy, operations of this kind, that one can execute in indefinite number, are in brief more specious than conclusive; However nothing prevents that sometimes a happy accident permits us to reestablish with some probability certain geometrical principles to which the architect proposed to subject the temple that he had to erect. The taste of the Greeks for geometrical theories authorizes this conjecture.

In this matter it would not be without importance to note that the dimensions of some very ancient temples can bi expressed in numbers by simple fractions, i.e., whose denominator is 2, 4, 8, 16, etc. Those divisions graphically drawn form what is termed a lattice. The plan of temple C of Selinonte corresponds to numbers of that kind.

The sides of its rectangle are in the ratio 45/16 with an error of less than.039 in. on the long side. It is proper to take with that edifice the temples S and D of the same city; they present 8/3 and 39/16 with errors of 1.97 and 2.76 ins. in their lengths. The old temple of Athena at Athens, as well as the temple of Poseidon at paestum, where t the sides respectively have the ratios of 17/8 and 21/8, with errors of 1.97 and 2.76 ins.

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Another remark must be added to the latter; this is that many temples exist, where the proportions of the sides are not expressed by simple numbers.

All that proves that the plans of these edifices were not established according to the same system of numbers nor by the same system of geometrical constructions. In the parallel of Table A, the temple of Concord is that, which best permits the suspicion of geometrical method. Its length is rigorously equal to four times the side of a regular decagon inscribed in a circle with a radius equal to the width of its facade.

It is not impossible that this result, geometrically accurate, may be historically true. That is the impression developed for a distinguished mathematician, M. Jules Tannery, by calculations, that he was quite willing to make on data that we furnished him; two of the operations belong to him, whose result was stated above. We take this occasion to thank him for his kindness.

General Proportions of Elevations.

To explain the principles of these proportions, we shall represent at the same scale two temples of very different sizes, such as those of Zeus at Olympia (Fig. 253) and of Egina (Fig. 254). One can believe that the Greeks in giving great dimensions to the facades of their temples, at the same time would have multiplied the architectural members and ornaments on the vast surfaces thus created. It is not so at all. The facade of the temple of Zeus bears neither a member nor an ornament more than that of the temple of Egina. Only the triglyphs, metopes and other members occupy in the former much larger surfaces than in the latter, but in conditions so that the second is not a reduction of the first.

If one divides the bases of the two temples into a certain number of equal parts, for example 12, the least attention allows him to see that although the proportions of height are unlike, yet they are comprised in both within 6 and 7 of those parts.

This mutual dependence in which are found the heights and widths up to a certain point, is the characteristic feature of the system of proportion applied by the Greeks to the f

facades of their temples.

But it is not the same for the side elevations. This peculiarity is easily explained, the diagrams of Table A have indeed shown us that all these edifeces have different proportions in length.

The various proportions in height for the principal temples are indicated in the diagram of Fig. 255, where all facades are made of equal height. To make the differences visible, draw through the mean diameter of the columns, i.e., the middle of their height a straight line, which is the diameter B B of a semicircle with centre E at the intersection of this straight line and the vertical axis of the facade D E. This semicircle very nearly determines the apex of the pedimenton the temple of Poseidon at Paestum; it passes more and more above that summit in the temples of Theseus and of Zeus, of Corinth and of Bassae, while it falls more and more below on those of Egina, Segeste, Nemea and of Demeter at Paestum. Between these temples are inserted those, that lacking space has prevented us from presenting.

Thus, it is with proportions of facades as with those of plans; all differ, all are comprised within very narrow limits, and neither are developed in a regular chronological order. One can verify this last observation by referring to the classifications that we have established, especially in series C and D.

We shall still have recourse to comparative tables to illustrate the peculiarities remaining to be made known.

The ratio of the height of the column to the width of the temple is indicated according to the order of time in the upper diagram of Table C (Pl. XLIX). All these proportions differ from each other, put they succeed each other in a continuity rising very irregularly. For example, the ratio is higher on the temple of Artemis at Syracuse (Pl. XLIX,3) than on the temples of Corinth and of Assos (Pl. XLIX,4,5). This diagram also shows that from the earliest to the latest temple, this ratio is nearly doubled.

It will perhaps have been noticed, that we introduced in the series of Table A, the perimeter of a monument of Paestum usually termed the basilica. That edifice is not a temple, but it has the average proportions of one. Now in the

upper diagram of Table C, one sees that the ratio of the height of its columns to the width of its facade is less than on the temples.[1]

Note 1.p.560. We persist in refusing to see a temple in the edifice of Paestum known under the name of basilica or great portico. Recently Koldewey has compared it with Ionic temples with two internal aisles, such as that of Neandria and the old temple of Locres (Neandria, p. 44-45). Here in brief are reasons why we cannot share that opinion.

1. As shown by the Table on Pl. C, the ratio between the height of the column and the width of the edifice in the basilica is less than the same ratio shown in the temples.

2. The arrangement presented by the edifice of Paestum has been much employed at all times for covered markets and porticos. There is usually at the middle of those edifices a spina or row of columns.

3. Finally, from what is found in Ionic temples, examples of division in two aisles by means of a middle row of columns, it does not follow that the same arrangement may have ever been adopted for the Doric temple. The Ionic style, as we shall see, was early subject to the influence of the Doric style; but it is impossible to find a trace of the influence that the Ionic exerted on the Doric. In the latter, the cella has always retained the form due of the imitation of the megaron.

This peculiarity warns us that in the Doric style the proportions profoundly differ, according as they were applied to temples or to edifices for another purpose.

Likewise in a chronological series are indicated in the lower diagram of Table C the dimensions in the height of both entablatures and of columns.[1] Some of the latter are not represented in the upper diagram because they belong to edifices, whose ruinous condition has not allowed the plan to be recognized. Such are the columns of the temple of Tarente (Fig. 261) and those engaged in the walls of church S. Maria at Syracuse.

The Table that we examine emphasizes the very moderate dimensions of Doric temples. In fifteen of those edifices, the height of the columns exceeds 23.0 ft. and in thirteen others that height does not reach 36.0 ft. The considerable height of the column of the temple of Giants is explained

by t

by the exceptional construction of that edifice.

Note 1.p.563. In all these Figs. the height of the entablature does not comprise the height of the cyma.

Let us now seek the different ratios that exist between the diameter and height of columns, and between the same d diameter and the height of the entablature. These ratios a are indicated in the lower part of Table D (Pl. L), the diameter being the same for all the columns.[2] The study of this diagram causes us to recognize some remarkable peculiarities.

Note 2.p.563. The temple seen under No. 18 and thus designated as Hera of Agrigente is that frequently called Juno Lucina.

1. In each temple the columns have a proportion very suitable to them, or otherwise stated, the proportions of those supports are different in all the sacred edifices. The lowest ratio is 4.063 and the highest is 6.471.

2. Nearly always the height of the entablature diminishes as the height of the column increases; but the undulating lines that crown the ordinates in the two diagrams of the Table, shows that this diminution does not operate according to a constant ratio in all the temples. The heghest ratio is 2.45 and the least is 1.71.

These two extreme rations correspond neither to the smallest nor to the largest proportions of the columns.

In the lower diagram of Table D, these same ratios follow in the order of heights.

As a summary, the care to diversify the temples was carried so far among the Greeks that they never employed twice the same general proportions in these edifices. The study of our Tables allows the formulation of this conclusion with the most entire certainty.

The Modulary System.

It should not be supposed because the Doric temples are dissimilar, that in each of these edifices the proportions were established by chance; on the con.rary, they correspond to a body of canonical rules, whose theory Vitruvius has given so awkwardly, that it was almost misunderstood by the architects of the Renaissance as well as by their modeen successors.

The passages of the text of that author in which he expa-

expatiates on the proportions are not connected together. Further, they frequently present a certain obscurity of expression. But Vitruvius had read the treatises of Greek architects lost to us, and only in his book is it now possible to find rather precise ideas on the architectural proportions employed by the ancients.[1]

Note 1.p.564. This is not the place to discuss the question of more or less importance to be attached to the authority of Vitruvius. What is certain is, that while particularly devoting himself to teach the system of proportions employed in his time, he had in his hands the treatises of Grecian architects, in which they explained their practice and the rules that they had applied. He cites Silenos, Theodoros, Chersiphron and Metagenes, Ictinos and Carpion, etc. (VII, 12). Had he sufficiently studied and always fully understood the texts of those authors? It is difficult to say; none of those treatises has come down to us. In any case, the terms used by him in great part are borrowed from the nomenclature created by those architects; he has derived from their works more than one useful suggestion, that the study of t the monuments permits us to utilize better that the commentators of the Renaissance can have done. It is thus for those symmetries of which he speaks, and which virtually contain the entire theory of those auxiliary modules, to which we shall have occasion to return. (Chipiez. Le systeme modulaire et les proportions dans l'architecture grecque. Revue archaeologique. Vol. XIX, 1891). With some attention and s some precaution, one can detach from his essertions the elements of an architectural doctrine, the modulary system, which indeed is that of the Greek masters. The basis of this system is certainly very ancient; but the rules relating to numerical ratios have varied from age to age. It is the same with certain classifications; thus for example, it would be useless to seek to apply to the Doric temples of the 6 th and 5 th centuries what Vitruvius gives of the different kinds of intercolumniations; with the Ionic monuments of t the Hellenistic epoch, one would find least difficulty in making them agree.

We shall state briefly and in a concistent and systematic form the method of proportions, whose elements are scattered

in the treatise of the Roman architect.

By means of the module, and by following a particular method, the Greeks fixed the different proportions of the edifice.

The module is a linear measure that must be comprised a certain number of times in a given dimension of height or width. The dimension must be divided by the module as the width of the monument for temples, the diameter of the orchestra for theatres, the height of the column for porticos, etc.

Figs. 256 and 257 show the effects that result from the use of the module used for heights. The first represents the facade of the propyleion of Sunion, and the second is the portico of Philip at Delos.

Those two monuments have nearly the same height. If one divides it into a certain number of equal parts, i.e., modules, he sees that the base A B contains a number of modules very much less than C D of the portico of Philip. Consequently in the case where the module is employed in that f fashion, the widths may have the most different proportions with relation to the height, i.e., the first are not proportional to the second.

Quite otherwise are the effects of the module of the temples. When in those edifices the widths are extended, the heights increase in proportion or nearly so. This is proved by the temples of Egina and of Olympia represented in Figs. 253 and 254. In the last edifice, the dimension of the module increases at the same time as the width of the facade, and the columns are enlarged in height and diameter, like the other architectural members.

The number of modules that must be comprised in the width of temples differs according to the style of the architecture of the monuments, and the number of columns that enter into the composition of their facades. It follows that the module is a variable measure, but not arbitrary, since it must always divide a given dimension intn a desired number of equal parts.

In principle, the column must have so many modules and t the capital so many. It is the same for the architrave, frieze, cornice and the other parts of the edifice.

Besides, the Roman architect desires the module to correspond to a dimension of certain members of the edifice, such as the diameter of the column, or the width of the triglyph in the Doric order.

But that is not all. The general module being once fixed, Vitruvius subordinates its use to the absolute dimensions of the temple. For example, if the column has a height of 15 ft., the architrave will have a height equal to half the lower diameter of the shaft; while if it is 20 ft. high, it is necessary to divide this into 13 parts, one of which will give the height of the architrave. (Fig. 258, right hand).

Likewise the greater or lesser width of the intercolumniations will change the proportion of height for the columns of the same order. The narrowest intercolumniation (pycnostyle, 1 1/2 modules) must have columns 10 modules in height (Fig. 258, left), and the widest (aerostyle) columns only 8 modules.

Note 1.p.568. Vitruvius. III. c, 10.

It has been proposed to give the name of corrective canons to the rules that modify the typical proportions.[2]

Note 2.p.568. Ch. Chipiez. Le systeme modulaire.

Finally, for each division of the members of an edifice, Vitruvius prescribes a special law of subdivision, which gives rise to measures that have been termed auxiliary modules.[3]

Note 3.p.568. The same.

Let the height of the Ionic architrave be fixed according to the canonical rules.

To obtain the proportions of the mouldings of this architrave, it is necessary to divide it vertically into 7 equal parts; one of these parts will be the height of the cymatium that crowns it. Then one will divide the remaining 6 into 12. Three of these parts will be the height of the lower facia, four that of the middle, and 5 that of the upper facia of this architrave. The other members of the order will be determined in a similar manner.[4]

Note 4.p.568. Vitruvius. III, 5, 10.

By the use of this sort of modules, one obtains as many different scales as are necessary to establish the architectural members, whose proportions are derived from each other,

and one of those determines simple measures, but which would not retain the character, if one thinks of basing them on the module divided into 12 or 16 parts, according to the c custom of the moderns. The auxiliary modules may be very d dissimilar; but it is no less true that they always proceed from a primary measure, that they have in it their origin and starting point.

In these conditions one can no longer attach to the module, the primary unit, the narrow idea of an inflexible scale of proportion. By the use of a particular mode of subdivision, the modular system ceases to be a formula to become a method. By it is explained in great part the extreme diversity in proportions, that we have observed in the temples; it explains why in certain cases the members of those edifices are not similar, even when they so appear at first sight.

Practices so ingeniously combined could originate and be implanted only in a people exceptionally endowed for art. Vitruvius does not hesitate to attribute the merit of them to the Hellenes.

These remarks were necessary; they even enable us to undertake the analytical study of the other proportions of t the temple in the course of this history.

The two adjacent Tables contain in numerical form all the facts that are presented in graphical form in our Tables.

Note. p. 569. It is necessary to correct in Tables A and B the dimensions of the temple of Egina; 41.54 x 90.78 ft.; the plan of this temple should come immediately after that of the temple of the Giants in Table A.

15. Polychrome Ornamentation.

When one observes today the best preserved of the monuments of Greek architecture, they now offer to the eyes only a uniform color. This is either as at Assos the brown of a volcanic stone, or as in the ruins of Sicily the grayish tint of calcareous tufa; on the temples of Attica, it is t the whiteness of marble. For a very long time modern architects were deceived by this appearance. When they attempted to imagine those edifices as they must have shown themselves to the eyes of the people who built them, they represented and restored them like the edifices, which they were accustomed to construct, allowing the natural color of the stone

to be seen everywhere, both on the large areas of the walls as in the hollows of the mouldings. If they attempted to restore them, they only counted on the work of the chisel and on the play of shadow and light, to accent the main lines of the structure, to emphasize the mouldings and to model their ornaments.

Only about the middle of the last century (19 th) did men think of asking if it were true that the antique temples in their fresh newness, presented that uniform and monochrome appearance. The first that proposed the question, to entirely solve it immediately, was an architect of German origin, Hittorf, but established in France. He undertook in 1823 a and 1824 to study what remained of the ancient monuments of Sicily, to measure and draw their plans, elevations and details. In the course of those labors, two kinds of facts attracted his attention. On the one hand, he noticed certain fragments of terra cotta covering tiles and facing slabs that were ornamented by designs executed by means of colors that firing had fixed on the clay. On the other hand, by examining with minute care the surfaces of the mouldings of the architectural members, he frequently perceived on t the lower sheltered surface of a moulding or in a recess of their reentrant curves, traces of colors formerly applied on the stucco that covered the stone. Those unexpected discoveries excited his curiosity; he found the same colors,, better marked and more vivid, on the remains of the frieze or cornice.

Hittorf was convinced. From that moment it was proved to him that antique architecture was polychrome, i.e., that in its system of decoration, it assigned an important part to color and its variations. On his return, he hastened to communicate his discoveries to all, that they could interest, to explain the theory that they had suggested to him, and propose its adoption to learned men and artists. To convince the incredulous, he exhibited fragments that he had brought, where were still discerned some vestiges of f former coloring; he showed drawings made on the spot at t the time of excavation, before the fading colors, which then diminished rapidly and ended by vanishing. To reply in advance to the objections based on the singular effects, t

that must be produced by that variety of colors, he presented restorations executed in that spirit, and he added to all that graphical apparatus memoirs in which he invoked both arguments of facts and reasons of feeling and taste. All those materials, dissertations and drawings, furnished him with materials of the work later published in 1851 under the title:- Restitution du temple d'Empedocle a Selinonte, ou l'architecture polychrome chez las Grecs, avec un atlas.[1]

Note 1.p.573. XVI+845 pp. Atlas in folio, 23 colored plates. Didot. Paris. One cannot imagine a book more badly prepared; instead of explaining his thesis methodically, with all the proofs for its support, the author scatters those proofs throughout long chapters, in which he discusses with numerous repetitions the objections presented by his principal opponent, Raoul-Rochette. The work no less retains great value by all the facts contained and especially by its plates, where are gathered many monuments then unpublished; b but the text might have been abridged by two-thirds without inconvenience.

Meantime the ideas of Hittorf had made their way, though very strongly opposed at first. In Germany the intelligent and learned architect Semper had accepted them and had confirmed them by his own remarks. One of the masters of archaeology in France, Letronne, became their avowed defender in the controversy sustained in that respect against Raoul=Rochette. Architects being once aroused, had found everywhere in edifices taken as the subject of studies, the remains of these colorings which their predecessors had been unable to see, because they did not look for them. Documents accumulated in recent years so as to remove the last doubts, that can have still remained in some minds convinced with difficulty.[2] A more extended and more accurate knowledge of the monuments of oriental art has demonstrated that everywhere, from Egypt to Chaldea and Assyria to Persia, architects had by various procedures covered with brilliant colors the facades and interiors of their edifices, that they had employed color to accent reliefs, and to better emphasize their general arrangement for the eyes of the spectator; this system was suggested or rather required from the artist

by even the intensity of the light of southern countries, by the violent reflections that lessen the value of cast shadows, and thus reduce the relief of the surfaces.[1] The conditions of the surroundings were nearly the same for Grecian art, and one further knows all that this art borrowed from Asia; how can it alone have mistaken those necessities of the climate, have refused to take into account t the sun, whose splendor must illuminate its buildings?

Note 2.p.573. One will find the entire history of the matter very well presented in Fenger, Dorische Polychromie, l large folio atlas of 8 plates and text in small folio of 48 pages (Berlin. 188_). This is in section 1:- Farbefunde und Ergänzungversuche. Before Hittorf, Fauvel after the beginning of the (19 th) century, had divined the part that color played in architecture and sculpture. These results from a several passages of his letters quoted in the interesting study devoted to that personage by F. Legrand in Revue architectonique (1897:- of Fr. Sebastien Fauvel. "The reliefs of the Parthenon and Theseion were painted," Fauvel writes; "each object, flesh, draperies, background, had its proper color. On all the mouldings of the two temples, the waterleaves, eggs, frets, all were painted." Fauvel saw the monuments in better preservation than they are today, he was an attentive and intelligent observer. Unfortunately, he published almost nothing; the ideas that he expressed on t this subject in his correspondence and conversation were n not repeated.

Note 1.p.574. Histoire de l'Art. Vol. I, p. 122-128; 775-77

The Greek architect did not commit that fault; from the first day he had the instinct and passion for color, in the same degree as his predecessors, the architects of Memphis and of Babylon. See that prehistoric Greece, that has just been restored to the light by the excavations of Schliemann and of Tsoundas; see the ruins of its tombs, houses and palaces. In the funerary domes at Mycenae, marble and other s stones of varied colors form a many-colored facing on the facades; overlays of metal cover the masonry in the interior of the dome; further, in the hypogeas excavated in the hill itself, the entire enclosure of the doorway is painted black and white, red and yellow. At tiryns and Mycenae, everywhere

in princely habitations, colored plastering conceals the poverty of the materials, and large frescos, actual pictures with numerous personages, extend on the walls of the principal rooms. About the same time other and no less interesting discoveries invite the historian to resume on new grounds the study of a period after the evolution of Hellenic genius: they transport him to the heart of the 6 th century, which invented and created so much, that gathered all the elements of the masterpieces, which were to blossom in in the succeding century. This was a revelation due to the excavations of Olympia, Selinonte and other fields of Sicilian ruins, that of the services which the decorator required from colored terra cotta; it was the exhumation, piece by piece, of the remains of the already very rich ornamentation, with which the Acropolis of Athens had been endowed by the generation preceding the Median wars, temples, statues, monuments of every kind composing that. From 1835 to 1838, there were found by hundreds architectural members, pieces of cornices, copings of pediments, steles and pedestals (Fig. 259), reliefs and statues. All those fragments have successively risen from the thick layer of rubbish formed on the plateau after the fires kindled by the Persians, and destructions designed to make room for new edifices erected by Cimon and Pericles. On all those remains, that were preserved intact in the layer of rubbish in which they were buried, gleamed the colors that sometimes still had much splendor, even at the time of discovery. Since then the colors incorporated with the clay have been preserved, almost without change. As for those applied on calcareous tufa or marble, men have endeavored to ensure their duration by covering them with a coat of varnish and by placing under glass the most important monuments. They have no less faded and perhaps will end by vanishing; but faithful copies, made on the morrow of excavation, have noted all their values and give their entire scale.[1] Thus it remains established, at least for the archaic period, that the architects and sculptors, the former on their edifices and the latter on their figures, made a very wide and very constant use of polychrome decoration.

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reproduced in color in vol. I of Antike Denkmäler, which the German Archaeologic Institute began to publish in 1886 (Pls. 18, 19, 29, 30, 38, 39, 50). We give some specimens in this volume (Pl. XLVI); we shall give others in the succeeding volume.

What those monuments have taught us of their ancient condition, one can already have divined from the indications of the literary and epigraphic texts. According to Vitruvius, on the wooden temple in which he sought the prototype of the Doric temple, a layer of blue wax was laid on the planks nailed to the ends of the beams, that served as models for the triglyphs of the stone temple;[1] that conjecture must have been suggested to the authors interpreted by him, by the triglyphs painted blue, that they had under their eyes. In Greek and Roman writers, there is frequent mention of mural paintings, works of celebrated artists, which decorate both porticos and temples.[2] For those paintings, into which entered all the colors that the painter then grouped on his palette, was required surroundings in harmony with them, that of flat or projecting borders and a darker tone, on which was detached in light the field on which was displayed that series of images. The intervention of the historical painter, as we should say, assumed that of the painter of buildings; the latter had to place his ornamentation in harmony with the work of the masters with which he was associated by the will of the architect, by whom was regulated the entire arrangement of that complex and beautiful entirety.

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state it in formal terms. Fortunately the inscriptions are more explicit; in the accounts of the restoration of the Erectheion undertaken in 385, one finds mention of the salary paid to the workman,"who painted in encaustic the cymatium on the architrave of the interior;" there are also mentioned the leaves of metal purchased "to gild the eyes (of the volutes) of the column."[3]

Note 3.p.576. C. I. A. I-324. See the translations of these inscriptions given by M. Choisy in his Etudes epigraphiques sur l'architecture grecque. III, p. 119, 133.

Since attention was called to these peculiarities, there has scarcely been a single excavation of any importance, t that has not brought new arguments to support the doctrine, at first opposed by such passionate denials. Today one no longer meets any person, that contests the principle of the polychromy of ancient edifices. Those who first supported it would perhaps hesitate, if they were still living, to follow to the end those who present themselves as their disciples and followers. It often occurs that new converts exceed moderation. One knows that personage of Boileau, who boasted of having placed nutmeg in all the dishes to honor the guests. More than one architect today acts in the fashion of the Repas ridicule.

Do you love color? It is placed everywhere, he will voluntarily inscribe below his sashes, when he undertakes to show by a series of designs, what might have been in its first splendor, some one of the most beautiful edifices of antiquity. To the objections presented by the archaeologist, the artist sometimes contents himself with replying, that the effect so obtained is most happy, and that he needs nothing more.[1]

Note 1.p.577. "I have only one reason, that I have to enforce. In my eyes it is superior to all others; polychromy is good; it is beautiful." E. Loviot. L'Architecture. 1889,83

The historian of art cannot place himself at that point of view. What is important to him is not to seek what is the richest and most sumptuous ornamentation, that the imagination of the decorator could invent for an edifice like the Parthenon; it is to know by the study of the monuments and by that alone what was the practice of the Greeks in that

to that entablature, its surfaces and mouldings was it important to ensure the benefit of the virtues of color, by c calling on that to correct in a certain manner the perceptions of sight. Thanks to the intensity and variety of tones, the architect thus corrected singly all the lines of the d design of the mouldings; he called attention to the correspondences and the contrasts by which were indicated the proportions, that certain analogies or certain differences in function established between the different members of that entirety. The effect of diminution and reduction produced by distance thus found itself corrected; the vigor of the local coloring gave to each motive its independence and its full value; it singularly accented the fineness of the outlines.

What ended in calling in the intervention of color was t the character of the architectural members composing the e entablature. Among these was scarcely more than a single o one, the triglyphs, which was so composed as to be able to do without color, it seemed. Aside from them, the contrasts of shadow and of light arranged in the hollows and the very boldly modeled reliefs would have sufficed to make apparent to the eye the design and rhythm, even very far away; but what is true of the principal member of the frieze is not so to the same degree of two other parts of the Doric entablature. In the architrave and particularly in the cornice are the drops, narrow fillets, then tablets and light cymatiums. Each of these elements of small dimensions and of l less accented form gains much by distinguishing it from its neighbors by a coloring appropriate to it; by that alone it retains its importance and its expressive value, however h high it may be placed

Finally, it is not alone by reasons of taste, that is justified the method taken there by the architect; it is also explained by the history itself of the art. Wood furnished to the constructors of the most ancient temples their columns and entablatures. That portion of the building was most exposed to storms; to protect it from them, men commenced by painting; later, they frequently had recourse to the use of terra cotta. Having given the facility with which color is placed on clay and remains forever when once fixed by fir

the facings, first adopted for the protection that they en-
sured, did not fail to be utilized for another purpose. The
brush of the ceramic painter laid on it palmatiums, flowers
and rosettes, plaits and frets; this rich ornamentation is
especially applied to the cornice, quite particularly to it.
The effect thus obtained seemed happier; thus in certain re-
gions of the Grecian world, men thought of fitting these s
slabs of terra cotta to buildings, that from the nature of
their material did not seem to demand that sort of complem-
ent; men had come in Italy as in Sicily to contribute to t
the embellishment of more than one temple entirely construc-
ted of calcareous tufa, and there again the roof and the up-
per part of the entablature were fitted with these facings. The
eye was thus accustomed to see color bloom on the surfaces
of mouldings of the crown; it would have been out of its e
element if not found there, at this same place, on temples
where the architect had concealed from top to bottom the c
coarse grain of the stone under a layer of stucco. This st-
ucco lent itself to receive a coloring, that gave the equi-
valent of what had been demanded elsewhere from slabs of
terra cotta.

In this matter it is important to distinguish what has o
been formally observed and can be made a general rule, from
what appears hypothetical or only in the state of an excep-
tion. See in what terms R. Borrmann expresses himself on t
this subject, one of the architects participating in the l
long labors of the excavations of Olympia. We have the res-
ult of his experience and personal observations;- "Taking
into account only facts, it is proved, that the Doric style
follows fixed rules that are everywhere respected, when it
applies color to various architectural members. For a great
number of monuments and particularly for most of the edifi-
ces of Olympia, of those built of shelly limestone, it is a
settled question except that of the coloring of the plane
surfaces of the wall and of the shafts of the columns; eve-
rywhere was there as a ground the light and white tone of
the stucco. No indication gives reason to think, at least
on the buildings of Olympia, that leaves were ever painted
on the echinus of Doric capitals. There were found in our
excavations many very well preserwed capitals, even several

appearing as if just from the hands of the workman; none of them showed the least trace of color not even of ornaments sketched on the stone; all that is observed is that the fillets cut at the base of the echinus were colored red. On the parts of the building that received a uniform color without ornaments, for example on the triglyphs, frequently if not always, the color seemed to have been mixed with stucco. For the Doric entablature, one is authorized to establish as a rule with reservations and exceptions that may present themselves; there were constantly painted red the fillet of the architrave, the inclined soffit of the cornice bed, the mutules, the small receding surface of the lower part of the cornice, and finally the lower moulding of the cornice, where it had not received a special ornamentation, in other terms the narrow band on which rested the mutules. The stucco ordinarily appeared in its light color on the vertical face of the band between the mutules.[1] The same regularity for the fillet that bore the drops on the architrave and for the mutule to which they are attached in the cornice, as well as for the triglyphs; all that was painted a blue more or less dark. The drops were most frequently red, sometimes also of the natural color of the stucco; it also occurred that they were painted yellow or gilded. One divines certain correspondances arranged in the coloring between the members forming counterparts in the general arrangement of the structure. The little cymas of the cornice and of the capital of the ante are ordinarily decorated by painted leaves. The ground of the metopes was colored only when it served as a ground for sculpture; it was then red or blue; otherwise it remained white. The grounds of the pediments and those of the sculptured friezes were generally painted red or light blue."[1]

Note 1.p.580. This assertion does not fail to surprise one; those little surfaces remaining white must produce the effect of spots on the red and blue grounds of this rich cornice.

Note 2.p.581. Berlin phil. Wochenschrift. 1895. p. 49, 50. In the study that Borrmann devoted to the second edition of Durm's manual, whom he reproached for having given too large a part to hypothesis in the statement, that he presents of the practice of polychromy). [illegible] the principles indicated by Borrmann the

indicated by Borrmann adheres the author of Plate CXII of the Baudenkmäler (Olympia, vol. I), a plate designed by Paul Gräf, and where is presented a restoration of an angle of the entablature of a treasury. The columns, their capitals, the architrave and even the cornice there retain the natural color of the stone or of the stucco imitating that tone. Colors are placed on the capital of the ante, on the hollow of the necking, on the frieze and on a part of the cornice. The polychrome decoration remains very sober.

If such is the nearly constant practice of the Greek architect during the entire duration of the classical age, these rules, as we were informed by the author himself of this statement, still do not fail to comprise certain variations and exceptions. Thus in the temple of Egina -- the fact seems well attested -- the pavement of the cella was covered by a layer of very red stucco.[2] As for the stylobate, there has never been perceived the least trace of color on the steps. For the columns, it is believed that on one of the shafts of temple E at Selinonte were distinguished three circular bands, a sort of belts, one of which was red, another white and the third blue;[3] but assuming the observations to be correct, the fact remains unique. Nowhere else has been indicated either red or blue on the drums. The only difference between the temples is, that the tone of the stucco in certain edifices, as at Egina and in most of the temples of Sicily and of Italy, is yellowish, while on the monuments of Olympia, it seems to have rather aimed to imitate the whiteness of marble. What is true of the column is likewise so of the walls of the cella; one finds there only a stucco that approximates more or less to the color of the stone. It is affirmed, that no leaves are painted on the echinus of any capitals discovered at Olympia, and we have no reason for doubting that assertion; but it is no less true, that on several capitals of Paestum have been found small ornaments, leaves and flowers, whose relief is scarcely sensible (Pl. XXVI). Due to a special coloring, some vestiges of which are elsewhere discovered on the stucco, these ornaments are detached from the ground; without it they would have been scarcely visible.[1] These plant ornaments have been sought in vain on the echinus of the capitals

Note 1.p.582. On these traces of color below the echinus of the capitals of Paestum, Hittorf, Arch. poly. p.45, Note 1; Garnier, Le Temple de Jupiter Panhellenion, p. 18.

Note 2.p.582. Ch. Garnier. The same. 1889. Pls IX, X.

Note 3.p.582. The same. p.18.

Note 4.p.582. The same. p.19.

Note 5.p.582. We should state that Fenger in the restoration, that he gives of the entablature of Egina (Die Dorische Polychromie, Pl. I), in spite of the example and the a assertions of Garnier, has not believed that the architrave should be colored red.

Note 6.p.582. Garnier. The same. p. 20.

There are other sensible differences between the tones t that fire incorporated with clay and those that the brush laid on the stucco. If the latter were as well preserved as the designs on the slabs of terra cotta, we should also perhaps discover, that the motives varied within certain limits, when the decorator changed the procedure. In any case, the palette of the ceramic painter was poorer than that of the painter of buildings. The first only employed four colors, white, black, yellow and red, the four colors according to the evidence of Pliny, that were alone used until the time of Alexander by the artists, that we would call historical painters, Zeuxis and Apelles (Pl. VIII, IX).[1] The second a adds to these fundamental colors blue and perhaps green. The blue is sometimes light and sometimes dark, and everywhere alternates with red in the ornamentation of Ionic c capitals and marble cymatiums, that were brought to light by the recent excavations on the Acropolis of Athens, and came from edifices ruined in the 6 th century;[2] numerous v vestiges have been found in the channels of the triglyphs of many Grecian temples. As for the green, one cannot deny that traces of it have not appeared on more than one monument;[3] but does it there represent accurately the original tone, that which the painter desired to place on the stucco or the marble? It is permissible to doubt this. All those who have handled those faience figurines, that Egyptian t tombs supply in thousands, have proved that on a number of them, the beautiful blue glaze with which the workman covered them, by the prolonged effect of time and dampness has turned green over the entire statuette, or sometimes only

on a part of its surface. It must be by an alteration of that kind, that it is necessary most frequently to explain the presence of green in what remains to us of the polychrome decoration of Greek edifices, thus on the cornice of t the old temple of Athena; if nearly everywhere the blue tint has become greenish, it has retained its original value in places; it is then allowable to restore this in the whole of the motive.[1] Green does not change to blue. On the other hand, by mixing yellow and blue, the painter obtained at p pleasure all the hues of green, and it is possible that on certain architectural members, for example on the cymas, p plant ornaments like leaves and flowers may have been sometimes made of green.

Note 1.p.583. The elements of Pl. VIII are borrowed from Pls. III and I of Dörpfeld. Ueber die Verwendung, etc. Pl. IX is executed after De Luynes and Debacq. Temples de Metaponte. For polychrome decoration executed by means of terra cotta, also consult Pls. CXV-CXXIV of Olympia. Baudenkmäles, Vol. I, and the description of those plates given by R. Borrmann, and enriched by numerous illustrations inserted in the text. On the terra cottas of Greece proper, see Fenger, p.24,

Note 2.p.583. Ant. Denkm. Vol. I, pls.18, 29, 38, 50.

Note 3.p.583. Green was found on the cornice and in the coffers of the temple of Nemesis at Rhamnus.(Uned. ant.of Attica. 1817. Chap. VI, referring to pls. 3 and 6.

Note 1.p.584. This is stated by the architect Wiegand, w who studied and published these fragments.(Ant. Denk. I, p. 28). In the representation of that cymatium given by him, he has restored the original blue. (Pl. 38, A^2).

Yet the decorator must have made but a very limited use of that color; he must have employed it only to bring into view a certain slight detail, in an elegant and complex ornamentation; it cannot render him the same services as red a and blue, aid him as efficiently in accenting the principal lines of the edifice, and what one can term the joints of the mouldings. Blue contrasts with red more frankly than green, it presents firmer and happier contrasts with it; also it everywhere replaces black, to which the ceramic painter had assigned such an important part in composition of his colored facings. By this substitution of blue for black, the

of the edifice. On the others it is replaced by black spots. Even where it has the most vivid hues, it presents very irregular spots and veins; it varies in intensity from one column to another. Chemical analysis has demonstrated that this tine is due to the creation of an oxide of hydrated iron, t that under the influence of the moist air and heat, is formed by the gradual decomposition of the skin of the marble, or even of certain other stones.[1] Neither the wind that drives the rain nor the rays of the sun equally strike all the facades 6f the building; it results that this alteration is every where produced in the same manner; consequently the f form and color of the oxide change with the orientation of the facades.

Note 1.p.585. Lepsius. Marmorstudien. p. 18, 121; Durm, p. 181, Note 150.

On slabs of terra cotta as in paintings executed on stucco or marble, the colors were laid flat beside each other, without intermidiate hues to form the transition; but the painter with a sure instinct knew how to avoid contrasts, that would have produced a disagreeable effect to the eye. Thus in ornaments the red and blue are ordinarily separated by a white and black band or by a narrow band of gold. Besides, where architectural members are concerned, such as the triglyph a and metope, one of which is colored white while the metope is frequently colored red, the two tones touch; but the surfaces are not in the same plane, and the cast shadows soften what hardness that juxtaposition might have. One can further count on distance to lessen the boldness of certain contrasts to avoid all risk of violence and excess.

If one knows what tones served to establish that decoration he is less advanced in regard to the nature and chemical composition of the colors employed for that purpose. Here is w what was indicated by some analyses made of fragments of painted clay and of colored stucco collected in Sicily and at Athens.[1] The white is white lead or chalk, the black being burnt iron or calcined bone, what is termed animal black. Y Yellow is ochre. The red appears to have been sometimes an earthy oligist iron and more frequently natural cinnabar. As for the blue, it is a carbonate or silicate of copper, what Vitruvius calls blue of Alexandria, a paste which he gives

the recipe;[2] this is the blue likewise used by the sculptors of Athens in the 6 th century, and later by the coroplastes of Tanagre for coloring sometimes the nudes and always the draperies of their statuettes or figurines.

Note 1.p.586. Hittorf. Arch. poly. Chap. 74. Rayet. Bull. Soc. des Antiquaries. 1880. p. 169.

Note 2.p.586. Vitruvius. VII, 2.

On temples of tufa, where as on the triglyphs or on the e entire length of an architrave one desired to have only a u uniform tone, the color was often mixed with the stucco, so that it did not risk disappearing as long as the latter continued to adhere to the stone. As for ornaments, such as palmatiums, flowers, scrolls, they can only be traced with the brush. By an inscription already cited, it is known that at least on marble, the work was done by the encaustic procedure, i.e., by means of colors mixed with wax, which were s spread on the ground by means of hot irons. The same document informs us that in certain very careful edifices, such as the Erechtheion, gilding was also employed; on the Doric order the drops were best suited to receive that ornamentation. The Greek architect does not seem to have known a practice very common among us, that consists in representing a fictitious masonry by lining the joints. This sort of trickery was not to his taste. The wall or column of tufa, when it was covered with stucco, rather assumed the appearance of a monolith.

Different methods were taken to execute the ornaments destined to vigorously detach themselves from a light ground (Smig. 260). The surfaces on which vestiges are found do not appear to have been treated in the same fashion always; it seems that the color was sometimes applied on the dry, and sometimes on fresh stucco. The motives were sometimes modeled in the stucco in very slight relief, which would scarcely be felt without the color laid on it; this was the case for the capitals of the basilica of Paestum decorated by leaves and flowers (Pl. XXVI). When one had to paint directly on the marble, the motive was often outlined by a very slight hollow sunk in the surface, that was then filled by a thin coat of color; this procedure seems to have been earliest employed. Besides, men were contented to trace with

the point the outline of the motive, and instead of polishing the marble within this outline, as done in the sunken hollow, the surface was pointed with very light blows, so as to obtain a grain to which the coloring matter attached and fixed itself. Finally, there are also marbles on which the ornament was traced by the brush in free hand, without a preliminary sketch. In the museum of the Acropolis at Athens, where are collected so many curious remains of the architecture of the Pisistratides, one finds examples of the use of three different procedures.

As indicated even by this diversity, it was necessary to endeavor to lay that painting on the marble and to fix it there; on the contrary was easier than to apply it to wood with every chance of duration. This was certainly done on t the structures of the Mycenaean ages, where wood held such a great place. Painting was at first employed for its preservative virtue, but at the same time it served to enliven the appearance of buildings by the variety of the tones, t that covered the panels and beams in the interiors as on the facades. Timber had since lost much ground, but in the parts of the edifice in which it had maintained its places and where it was visible, it certainly was covered by a coat of p paint. At the same time that it ensured preservation, it served to give an appearance that placed it in harmony with the entirety in which it played its part. In what remains of the marble ceilings of certain porticos have been found very apparent vestiges of color on the mouldings of the coffers, and sketches of certain motives, such as gold stars detached on a blue ground. Where the ceilings were of wood, the same tones and the same ornaments must have been applied on the small beams forming those compartments. In the interiors of t the cellas, in which were exposed around the chryselephantine statues a number of precious offerings, objects of gold, silver and ivory, one could not fail to give a decoration of some kind to the beams, that formed the framework of the ceiling above the single or three aisles of the sanctuary.

There will be opportunity later to complete these brief indications, when we shall have to describe the edifices of t the 5 th century; but these now suffice to make understood the use that the Greek architect made of those colors, that

mark the differences of age or sex? Earths and stones, only the objects belonging to the mineral world sometimes have a uniform gray or brown color. Now an edifice by the forms of which is expressed the thought of a civilized people, an edifice that the genius of the master has modeled freely and with love, this expressive edifice, the child of both the collective soul and of individual initiative, is truly an organic body and a living being. Why did it not also present that variety of colors, which we find in the plant kingdom, in the plant as in the tree, in the animal kingdom, from the humblest zoophyte and the smallest insect to the great mammiferas and even to man? If the temple did not have its proper coloring, if it had offered to the eye only the abstract and monotonous whiteness of a stone, that everywhere remained like itself while fulfilling different functions, according to the place it occupied in the building, the temple would have been outside life, and that would not have been desired by the artist, who as the poet says, "is a creator after God."

16. List of principal Doric Temples preceding the Near 43

In the preceding pages we have had occasion to indicate f from different points of view the peculiarities, that characterize those of the Doric temples preceding the second third of the 5 th century, of which exist remains sufficiently important, for one to restore the plan entirely or in part, d define its style, and up to a certain point, fix its age by a probable conjecture. This not a special history of architecture; we cannot then devote here to each of these edifices a monograph that would require a lengthy extension. We have presented the general theory of the Doric style and the history of the progress of that art; it will suffice to add to that a series of brief notes, in which will reappear as arranged in the probable order of time, all the temples mentioned above and also some others.

Some brief indications will there recall the principal features peculiar to each monument, that form its originality. For the edifices from which we have borrowed our examples, references will be made to the general views, details and plans that have been given in the course of these studies. As for the monuments that have been cited, we shall add to

the mention made of them some brief bibliographical notes, that will indicate to the reader the works in which their remains are described. Finally, we shall insert in this list some illustrations, whose place would not be in the general explanation, that we have presented for the methods and procedures of Doric architecture.

Below all Figs. contained in the Chapter terminated by th this list, we have indicated the source from which they came. But that mention does not imply that we have servilely reproduced the drawing of the author, whose authority we invoke. Without adding anything or altering the documents, that we have placed in use, we have presented them in most cases in a manner to make them more intelligible; in brief, we have chosen our methods of representation. Thus the temples represented in lines in works especially intended for architects, have been rendered by us for effect, i.e., with the shadows comprised in them. the reader will thus much better take into account the character of the forms of the succession of the planes. It is the same for the numerous architectural details to which we have had to call attention, for example for the bases and capitals of columns or antes; if we had shown them as given by the works from which they were borrowed, the illustrations would have been intelligible only to persons accustomed to the methods of geometrical drawing. We have placed them in perspective; this mode of presentation permits the relief to be seen at first sight.[1]

Note 1.p.591. Temples that have not been mentioned in the course of the Chapter are marked by an asterisk. Abbreviations employed are&-- F, facade; C, dimensions; E A C, intercolumniations at angles

Heraion at Olympia. Intercolumniations. Facade (beginning at left); 10.9'; 11.5'; 11.9'; 11.75'; 10.52'. Internal columns at ends; 10613'; 10.7'. Two columns of the portico, 6 at ends, 18 at sides (angle columns are counted twice always). Inside are two rows of 8 columns. Two pronaos, front and rear.

Pls. IV; XII; XIV; XXV,2; XL,12; XLII,8,9; XLVI; XLVII,25; XLVIII; XLIX; Figs. 188, 189, 190, 191, 192, 193, 194, 195, 196, 204.

On the subject of the history and arrangement of the Heraion, the changes that it may have suffered in the course of

centuries, consult the

centuries, consult the memoir of Wernicke. Zur Geschichte d der Heraions, which forms the second part of his Olympische Beiträge. (Jahrb.von Inst. Archaeol). 1894. p. 101-114).

Temple of Tiryns. The temple erected on the site of the palace of Tiryns must have been one of the oldest monuments of Doric architecture in the Peloponessus, to judge from the little that remains of it, by the decoration of one of its ornamented tiles (Pl. XLV), and by the profile of its capital (Pl. XXIV,1,2). This is the most archaic in form and appearance, of all capitals of this order that have remained to us. It is distinguished by the width of the abacus; that is nearly equal to twice the diameter of the upper part of the shaft, a proportion already sensibly reduced in the temple of Corinth, and that one finds again only in the temple of Demeter at Paestum. (Schliemann and Dörpfeld. Tirynthe. p. 274-276).

Temple of Hera at Argos, or rather between Mycenae and Argos. This uas the principal religious centre of Argolis; there must have been from a very early time an important edifice; but of the first temple which was burned in 423, there remains only the substructure in Cyclopean masonry. The depth of the layer of cinders appears to indicate a building into whose construction wood entered for a large part.

Ch. Waldstein. Excavations of the American School of Athens at the Heraion of Argos. 1892. New York. 20 pp + 8 pls.

Temple of Cadacchio at Corfu. F. 6. Right side, 3 existing columns; left side with 6. Probably 12 columns on each side. 20 flutes. F, Internal columns; 5.8'; 7.48'; 7.48'; 5.8'. No rear pronaos. Frieze without triglyphs. Mouldings of very peculiar character. Pediment quite high. Pls. XLVII,8; XLVIII; XLIX,2; Figs. 248, 249.

All that is known of this curious edifice, of which nothing more remains, is due to the English architect Railton. (Antiq of Athens and other places in Greece, Sicily, etc. 1830.

Temple of Artemis ? at Syracuse. F. 6, C.17. Monolithic columns. Middle intercolumniation 8.02'. Portico of pronaos presents an arrangement analogous to that of temples C and S of Selinonte, but without the pseudodipteral arrangement. T Two columns between the ends of the walls of the cella forming antes. It seems that the cella was open at both ends.

Topografia archaeologica di Siracusa. p. 24, 379.

Temple D of Selinonte. F. 6c; C. 13. 20 flutes. Internal columns; F. 14.25′; 14.4′; 14.65′; 14.4′; 14.25′. E.A.C.14.2′. Other intercolumniations 14.7′. Pronaos deep, where antes a are formed by engaged columns. Opisthodome (whose meaning v varies among authors) for an enclosed room, that forms the rear part of the cella). No rear pronaos. Architrave composed of two blocks in height. At the sides, the width of the portico approaches what it would be in the pseudipteral arrangement. Cornice with great and small mutules, that have alternately 3 and 6 drops in front.

Pls. XXIV,4; 16, 17, 18; XXXII, 11; XXXVI; XXXVII, 15; XLVII; XLIX,6; L, 8; Figs. 212, 227.

Temple C of Selinonte. F. 6; C. 17. F. Intercolumniations 13.95′; 14.65′; 14.9′; 14.65′; 13.95′. C.E.A. 13.0′; then 12.73′ and 12.7′. The columns at the sides have diameters 6.69 ins less than on the facade. Repetition of columns of facade before the pronaos, an arrangement also found on temples S and T of Selinonte, as well as on the Artemesion of Syracuse. Pronaos without antes. Opisthodome. No rear pronaos. Metopes sculptured on the frieze of the principal facade (Fig. 261). Triglyphs and metopes have very nearly the same proportions, that approaches the square form. Mutules alternate in two dimensions with 3 and 6 drops in front.

For the study of temple C, add to Hittorf's description : the information contained in Notizie d. scavi, 1876. p. 107 and Pl. V; 1882, p. 325-336, Pls. IX, XX; 1884, p. 318-33c. With the last works the excavation was completed. Men tried to leave all the pieces where they fell. Numerous impressions of carved stones were found in the excavations in 1882 and give reason to think that the temple was that of Hercules; the image of Hercules and of his club are repeated on most of those impressions. There was in the temple a workshop of intaglios.

Pls. IV,4; VII,2; C; VIII; XVI; XXI,8; XXIV,6,8,21,22; XXXIII,10-13; XL,13; XLV; XLVII,26; XLVIII; XLIX,7; L,9; Figs. 226, 237.

* Temple of Hera Lacinia on the promontory south of Crotone in Italy. There remains today but a single column, still standing on the remains of a substructure formed of great blocks

in regular but unequal courses. The only descriptionthat has been given of this ruin is found in Francois Lenormant. La Grande Grece, Paysages et histoire. Vol. II, p. 216-221. We ex.ract from it what relates to the proportions of the column, which the author declares to be more ancient than those of the temples of Metaponte; "the shaft has 16 flutes, without entasis, but with a diminution of more than one sixth. The lower circumference is 18.4′, with 5.74′ for diameter. The total height of the column with its capital is 27.2′, i.e., 4 3/4 diameters and a small fraction. This is a proportion intermediate between that of the pretended temple of Artemis at Syracuse and of temples D and C of Selinonte, on the one hand, and on the other, of that of the great temple of Paestum as well as of temples A and E of Selinonte. The form of the capital, the enormous extent of its crushed echinus, the breadth and thickness of the abacus, all that approaches rather the first group of edifices than the second. It is also easy to prove on the ground, that the temple of the Lacinian promontory presents in its plan this unusual extension in length with relation to the width, which is the most striking characteristic of the so called temple of Artemis, and in a lesser degree of temple C. It is stated t that in the 16 th century the temple was still almost intact and had 48 columns. Now this number is just that presented by temple C, due to the double row of its front portico. Consequently, to have the number of columns that was seen there before it furnished the materials for the episcopal palace of Cotrone, it is necessary for the temple of Hera to have likewise had 17 on each side, and that like the edifices to which we have compared it, those columns were closer on the lateral facades than on the front and rear facades, so that the abacuses of the capitals nearly touched.

"It results from these observations that the column of the temple of Hera Lacinia is the most ancient example of Grecian architecture that exists on the Italian continent. The d edifice of which it is the last remnant can only have been constructed at about the end of the 7 th or beginning of the 6 th centuries."

* So called temple of Lycian Apollo at Metaponte (Chiesa di Sansone). F. 6, C. 12 columns. Height of columns 13.4′.

Lower diameter of shaft 4.44′. 20 flutes. Dimensions of edifice with substructure, 136′ × 73.8′. There were discovered in the ruins numerous fragments of terra cotta facings.

De Luynes and Debacq. Metaponte. Pls. 7-12. Lacava. Topografia e storia di Metaponte. Naples. 1891. Pls. 2-6. Sonte - Simone. Studi sugli avanzi di Metaponte. Bari. 1875.

Another temple of Metaponte (Tavola dei Palladini or Tem-tio delle colonne Paladine). There remain 10 columns on the left side and 5 on the right side. Probably F. 6, C. 12 columns. 20 flutes. Lower diameter of shaft 3.6′. Intercolumniations at the sides vary from 9.5 to 9.65′. The plan has not been entirely restored (Fig. 262); all that is known is, that the cella was divided into a naos (37′ long) and an opisthodome (12.7′). The architrave no longer has its cornice; it must have been two courses in height. For the form of the capital, there is not a perfect accord between the drawings of Debacq and those of Sonte-Simone.

Plates IX; XXIII,2,13,14; XXV,1; XLIX,8; L,10; Figs. 216, 220, 235.

De Luynes and Debacq. Metaponte, pls. 3-6. Sante Simone, Studi, etc.,pls. 1-4. Lacava, Topografia, pls. 8-10. Römische Mitt. Vol. VI. 1891. p. 363.

Temple of Demeter at Paestum. F. 6, C. 13 columns. 20 flutes. F. Internal columns, 3.61, 3.63, 3.62 .3.63, 3.61′. E.A.C, 3.63′ etc. The columns of the portico are very ancient. Beneath the echinus they have a gorge decorated by leaves. Opisthodome. No rear pronaos. The edifice was certainly built in the 6 th century, and appears to have been thoroughly restored much later. The entablature was then entirely rebuilt, except the lower part of the architrave. This architrave is in two courses; it has drops under the triglyphs, and it is separated from the frieze by a double moulding. The triglyphs are formed of slabs inserted in the frieze. This terminates at the angles with a part of a metope. The cornice is without mutules. The cornice has an abnormal projection. Its soffit is decorated by coffers that are repeated on the raking cornices of the pediment. These arrangements foreign to Grecian architecture permit one to recognize a restoration in the Roman period in the entire portion of the entablature above the lower course of the architrave.

columns. This is the sole temple where still exist and are partly preserved the two orders superposed in the interior of the cella. A round hole of small depth indicates the places of the drops on the mutules.

The ceiling of the cella was at a higher level than that of the portico. There can be no doubt on that point; this results from the examination of the remaining parts of the edifice. One will later see in temples of the same arrangement, but of a later epoch, that the carpentry of the roof a and of the ceilings could form the same entirety; the propor tions adopted have led to establish the ceiling between the tiebeams of the carpentry of the roof, and even rigorously all ceilings of the temple might have been at the same height. This is a hypothesis not beyond all probability; but as the temple of Paestum is the only one in which the internal colonnade remains, this conjecture can receive no direct confirmation. Besides, the system that we have adopted for the restoration of the carpentry of Paestum, may also have been applied to these less ancient temples; There is no improbability in assuming this. It is what we shall show later, particularly in relation to the temple of Zeus at Olympia. According to the restoration presented by the German architects the cella, its floor being raised with regard to that of the portico, would be that of all parts of the temple having the least height.

Pls. V; VII,3; XIV; XXI,1; XXIV,7,9; XXVIII; XXIX; XXXII, 10; XXXIII,7-9; XXXIX,2; XLI,9; XL,3; XLVII,19; XLVIII; XLIX, 12; L,14; Figs. 156, 131, 135, 200, 205, 206, 208, 217, 225, 229, 231, 233, 24_, 246, 255.

So called temple of Hercules at Agrigente. The most ancient of the temples of Agrigente (Fig. 265); may have been built soon after the founding of the city (580). F. 6; C. 14 columns according to Cockerell, 15 according to Durm. 24 flutes. On the capital the profile of the echinus forms an angle of 45 degrees.

Entablature high and heavy. pronaos in front and rear. Cella narrow and long. Pls. XV; XLIX,13; L,15.

Houel, Voyage pittoresque. Vol. GV, pl. 218. Antiquities of Athens and other places in Greece. 1830, Pl. 9. (Cockerell Serra di Falco. Vol. III, pls. 15-19. Hittorf. pl. 21,5.

Note 1.p.597. Names by which are designated the temples.
1, Zeus Polieus (in the midst of the structures of the modern city of Girgenti). 2, Demeter and Kore. Hera Lacinia. 4. Concord. 5. Hercules. 6. Asclepios. 7. Zeus Olympios. 8. Castor and Pollux. 9. Hephaestos.

Old temple of Athena on the Acropolis of Athens. F. 6; C, 12 columns. Intercolumniations, 12.25;15.15; 15.15; 15.15; 12.25'. 20 flutes. The building rests on a single step. Front and rear pronaos. The cella presents a very abnormal arrangement; it is divided in depth into three parts. First comes the naos properly so called, divided into thre aisles, Pl. XXX, C; it had one internal order. Behind are two rooms separated by a hall placed on the axis itself of the building (D and E). Beyond these chambers is an opisthodome, a large hall (F). The statue of the goddess was placed in the central aisle of the naos (C). The other rooms 'D, E, F) served as storerooms; until the completion of the Parthenon, they contained the treasures of Athena. This is the edifice known under the name of Hecatompedon in the 6 th and beginning of the 5 th centuries. Only the foundations remained at the time when the excavations were made, that laid bare the rock of the Acropolis. Some architectural members were found in place in those excavations; others had been again employed as materials in the enclosing walls of the Acropolis. The cornice was of marble; marble tiles covered the edifice.

To Dörpfeld is due the honor of having uncovered this edifice, and of having brought to light the important part that it played on the Acropolis of Pisistratus. The ideas that he has expressed on this subject have aroused enough controversy, that it is proper to give the list of the principal studies in which the questions have been discussed. There can be no doubts on but two points. Was the temple repaired and restored after the second Median war? Did it remain after the erection of the Erechtheum?

Dörpfeld, der alte Athena Tempel auf der Akropolis (Athen. Mitt. 1886, p. 337-351; 1887, p. 25-61, 190-211; 1890, p. 420-439; 1897, p. 159-178). E. Petersen in the same, 1887, p. 62-72. Ant. Denkm. I, pls. 1, 2. Penrose, Principles of Athenian Architecture. 1888. p. 5-6, pl. XLVI. Also see objection in an Article on the ancient Parthenon, Jour. Hell.

Acropolis in order to prepare the esplanade on which rose the Parthenon. There remains of that effort the polygonal wall, a considerable monument (Fig. 151). Among the rare fragments that it is believed can be attributed to the temple of Spintharos are some of tufa and some of marble; thus is confirmed the statement of Herodotus, according to which the Alcmeonides employed Parian for "the front part," doubtless that they were compelled to do so by their contract (V, 63). Men rarely employed marble until then except for sculpture; it was not without surprise and admiration that they saw the architect of the Alcmeonides use it in their construction; laborious efforts and heavy expenses were necessary to transport from Paros to Delphi all those blocks of marble.

By a series of calculations based on measuring the fragments of the few remaining triglyphs and metopes, it is believed that the dimensions of the temple were fixed in an entirely approximate manner. Measured on the stylobate, it was about 190 ft. long by 75.5 ft. wide, dimensions sensibly equal to those of the rebuilt temple. As to the internal arrangement, nothing could be known.

The columns were made of drums cut from fine and close grained tufa, that received inly a very thin coating composed of several coats of milk of lime. These drums averaged 1.97 to 2.03 ft. high, had 20 flutes, and a diameter varying from 4.36 to 5.54'. A fragment of a capital was found, which permits a restoration of it. It frankly has the profile of the 6 th century, the high abacus, a very flat echinus with a strongly rounded edge. The architrave was in two courses in height. There were found two fragments in Parian marble of the fillet crowning it and that bore the drops. The lower block has disappeared, those great blocks of marble having been recut for other purposes; but is has been found in tufa. Comparison of the marble fillet and the architrave of tufa gives for the total height of the architrave 4.36 ft. There is a piece of a triglyph of white marble; the height of this member must be 4.53 ft. By the examination of the mutules, one recognizes two types of triglyphs, one 2.72 and the other 2.95 ft. wide. The intercolumniations were not all equal. Two lions' heads, designed to serve as spouts, present characteristics of archaic art. From a fragment of a moulding that c

Lower diameter of shaft 4.44'. 20 flutes. Dimensions of edifice with substructure, 136' × 73.8'. There were discovered in the ruins numerous fragments of terra cotta facings.

De Luynes and Debacq. Metaponte. Pls. 7-12. Lacava. Topografia e storia di Metaponte. Naples. 1891. Pls. 2-6. Sonte - Simone. Studi sugli avanzi di Metaponte. Bari. 1875.

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Plates IX; XXIII,2,13,14; XXV,1; XLIX,8; L,10; Figs. 216, 220, 235.

De Luynes and Debacq. Metaponte, pls. 3-6. Sante Simone, Studi, etc.,pls. 1-4. Lacava, Topografia, pls. 8-10. Römische Mitt. Vol. VI. 1891. p. 363.

Temple of Demeter at Paestum. F. 6, C. 13 columns. 20 flutes. F. Internal columns, 8.61, 8.63, 8.62 .8.63, 8.61'. E.A.C, 8.63' etc. The columns of the portico are very ancient. Beneath the echinus they have a gorge decorated by leaves. Opisthodome. No rear pronaos. The edifice was certainly built in the 6 th century, and appears to have been thoroughly restored much later. The entablature was then entirely rebuilt, except the lower part of the architrave. This architrave is in two courses; it has drops under the triglyphs, and it is separated from the frieze by a double moulding. The triglyphs are formed of slabs inserted in the frieze. This terminates at the angles with a part of a metope. The cornice is without mutules. The cornice has an abnormal projection. Its soffit is decorated by coffers that are repeated on the raking cornices of the pediment. These arrangements foreign to Grecian architecture permit one to recognize a restoration in the Roman period in the entire portion of the entablature above the lower course of the architrave.

The arrangement presented by the pronaos remains uncertain. The actual condition suggested to Lagardette and to Labrouste two very different restorations. Before the entrance of the cella are columns with 24 flutes and bases, whose capitals have not been found; it is not known to what order they belonged. It is possible that they date from the late restoration, and that the entire front portion of the building may have then received a new arrangement. In any case, there was never a rear pronaos.

Pls. XXVI,9-12; XLVII,14; XLVIII; XLIX,9; L,11; Figs. 210, 215, 223.

Temple S at Selinonte. F. 6; C. 14 columns. F. Intercolumniations, 14.43, 14.63, 15.15, 14.63, 14.43'. E.A.C. 14.75, 15.1', etc. Cella very narrow. lateral porticos have nearly the width of those of the pseudodipteral. No rear pronaos. Metopes sculptured on the frieze of the facade.

Pls. XVI; XXIV,5,10,19,20; XXXVI; XXXVII; XXXVIII; XLI,9; XLVII,23; XLVIII; XLIX;10; Figs. 219, 228, 234.

Temple T at Selinonte. F. 8; C. 17 columns, according to Hittorf, 16 according to Courtepee. In the interior are two rows of 10 columns according to Hittorf, 9 according to Courtepee (Fig. 264). This temple is one of the largest that the ancients built, and may perhaps be regarded as pseudodipteral. Its wide porticos place at the service of the public an area of 27,960 sq. ft. The edifice measured with the substructore is 392' long by 175' wide. Pronaos enclosed by columns on three sides. Rear pronaos. Construction dates from two epochs. The facade is the oldest part and is contemporaneous with temples C and D. The construction seems to have been interrupted, then resumed in the 5 th century, when temple R was built. Very marked differences distinguish the columns of the principal facade, of the lateral facades and of the pronaos from those of the rear facade and of the rear pronaos.

Pls. XVII; XXXII,5-9; XLVII,11; XLVIII; XLIX,11; L,13; Figs. 232, 264.

So called temple of Poseidon at Paestum. Facade intercolumniations; 14.2; 14.64; 14.64; 14.64; 14.2'.

Sides; intercolumniations at angles 13.9'; others 14.26'. Number of columns of portico 6 × 11. Interior, 2 rows of

columns. This is the sole temple where still exist and are partly preserved the two orders superposed in the interior of the cella. A round hole of small depth indicates the places of the drops on the mutules.

The ceiling of the cella was at a higher level than that of the portico. There can be no doubt on that point; this results from the examination of the remaining parts of the edifice. One will later see in temples of the same arrangement, but of a later epoch, that the carpentry of the roof a and of the ceilings could form the same entirety; the proportions adopted have led to establish the ceiling between the tiebeams of the carpentry of the roof, and even rigorously all ceilings of the temple might have been at the same height. This is a hypothesis not beyond all probability; but as the temple of Paestum is the only one in which the internal colonnade remains, this conjecture can receive no direct confirmation. Besides, the system that we have adopted for the restoration of the carpentry of Paestum, may also have been applied to these less ancient temples; There is no improbability in assuming this. It is what we shall show later, particularly in relation to the temple of Zeus at Olympia. According to the restoration presented by the German architects the cella, its floor being raised with regard to that of the portico, would be that of all parts of the temple having the least height.

Pls. V; VII,3; XIV; XXI,1; XXIV,7,9; XXVIII; XXIX; XXXII, 10; XXXIII,7-9; XXXIX,2; XLI,9; XL,3; XLVII,19; XLVIII;XLI.., 12; L,14; Figs. 156, 131, 135, 200, 205, 206, 208, 217, 225, 229, 231, 233, 24., 246, 255.

So called temple of Hercules at Agrigente. The most ancient of the temples of Agrigente (Fig. 265); may have been built soon after the founding of the city (580). F. 6; C. 14 columns according to Cockerell, 15 according to Durm. 24 flutes. On the capital the profile of the echinus forms an angle of 45 degrees.

Entablature high and heavy. pronaos in front and rear. Cella narrow and long. Pls. XV; XLIX,13; L,15.

Houel, Voyage pittoresque. Vol. GV, pl. 218. Antiquities of Athens and other places in Greece. 1830, Pl. 9. (Cockerell Serra di Falco. Vol. III, pls. 15-19. Hittorf. pl. 21,5.

Note 1.p.597. Names by which are designated the temples. 1, Zeus Polieus (in the midst of the structures of the modern city of Girgenti). 2, Demeter and Kore. Hera Lacinia. 4. Concord. 5. Hercules. 6. Asclepios. 7. Zeus Olympios. 8. Castor and Pollux. 9. Hephaestos.

Old temple of Athena on the Acropolis of Athens. F. 6; C, 12 columns. Intercolumniations, 12.25;15.15; 15.15; 15.15; 12.25'. 20 flutes. The building rests on a single step. Front and rear pronaos. The cella presents a very abnormal aerangement; it is divided in depth into three parts. First comes the naos properly so called, divided into thre aisles, Pl. XXX, C; it had one internal order. Behind are two rooms separated by a hall placed on the axis itself of the building (D and E). Beyond these chambers is an opisthodome, a large hall (F). The statue of the goddess was placed in the central aisle of the naos (C). The other rooms 'D, E, F) served as storerooms; until the completion of the Parthenon, they contained the treasures of Athena. This is the edifice known under the name of Hecatompedon in the 6 th and beginning of the 5 th . centuries. Only the foundations remained at the time when the exacaations were made, that laid bare the rock of the Acropolis. Some architectural members were found in place in those excavations; others had been again employed as materials in the enclosing walls of the Acropolis. The cornice was of marble; marble tiles covered the edifice.

To Dörpfeld is due the honor of having uncovered this edifice, and of having brought to light the important part that it played on the Acropolis of Pisistratus. The ideas that he has expressed on this subject have aroused enough controversy, that it is proper to give the list of the principal studies in which the questions have been discussed. There can be no doubts on but two points. Was the temple repaired and restored after the second Median war? Did it remain after t the erection of the Erechtheum?

Dörpfeld, der alte Athena Tempel auf der Akropolis (Athen. Mitt. 1886, p. 337-351; 1887, p. 25-61, 190-211; 1890, p. 420-439; 1897, p. 159-178). E. Petersen in the same, 1887, p. 62-72. Ant. Denkm. I, pls. 1, 2. Penrose, Principles of Athenian Architecture. 1888. p. 5-6, pl. XLVI. Also see objection in an Article on the ancient Parthenon, Jour. Hell.

Topografia archaeologica di Siracusa. p. 24, 379.

Temple D of Selinonte. F. 6c; C. 13. 20 flutes. Internal columns; F. 14.25'; 14.4'; 14.65'; 14.4'; 14.25'. E.A.C.14.2' Other intercolumniations 14.7'. Pronaos deep, where antes a are formed by engaged columns. Opisthodome (whose meaning v varies among authors) for an enclosed room, that forms the rear part of the cella). No rear pronaos. Architrave composed of two blocks in height. At the sides, the width of the portico approaches what it would be in the pseudipteral arrangement. Cornice with great and small mutules, that have alternately 3 and 6 drops in front.

Pls. XXIV,4; 16, 17, 18; XXXII, 11; XXXVI; XXXVII, 15; XLVII; XLIX,6; L, 8; Figs. 212, 227.

Temple C of Selinonte. F. 6; C. 17. F. Intercolumniations 13.95'; 14.65'; 14.9'; 14.65'; 13.95'. C.E.A. 13.0'; then 12.73' and 12.7'. The columns at the sides have diameters 6.69 ins less than on the facade. Repetition of columns of facade before the pronaos, an arrangement also found on temples S and T of Selinonte, as well as on the Artemesion of Syracuse. Pronaos without antes. Opisthodome. No rear pronaos. Metopes sculptured on the frieze of the principal facade (Fig. 261). Triglyphs and metopes have very nearly the same proportions, that approaches the square form. Mutules alternate in two dimensions with 3 and 6 drops in front.

For the study of temple C, add to Hittorf's description t the information contained in Notizie d. scavi, 1876. p. 107 and Pl. V; 1882, p. 325-336, Pls. IX, XX; 1884, p. 318-336. With the last works the excavation was completed. Men tried to leave all the pieces where they fell. Numerous impressions of carved stones were found in the excavations in 1882 and give reason to think that the temple was that of Hercules; the image of Hercules and of his club are repeated on most of those impressions. There was in the temple a workshop of intaglios.

Pls. IV,4; VII,2; C; VIII; XVI; XXI,8; XXIV,6,8,21,22; XXXIII,10-13; XL,13; XLV; XLVII,26; XLVIII; XLIX,7; L,9; Figs. 226, 237.

* Temple of Hera Lacinia on the promontory south of Crotone in Italy. There remains today but a single column, still standing on the remains of a substructure formed of great blocks

in regular but unequal courses. The only descriptionthat has been given of this ruin is found in Francois Lenormant. La Grande Grece, Paysages et histoire. Vol. II, p. 216-221. We extract from it what relates to the proportions of the column, which the author declares to be more ancient than those of the temples of Metaponte; "the shaft has 16 flutes, without entasis, but with a diminution of more than one sixth. The lower circumference is 18.4', with 5.74' for diameter. The total height of the column with its capital is 27.2', i.e., 4 3/4 diameters and a small fraction. This is a proportion intermediate between that of the pretended temple of Artemis at Syracuse and of temples D and C of Selinonte, on the one hand, and on the other, of that of the great temple of Paestum as well as of temples A and E of Selinonte. The form of the capital, the enormous extent of its crushed echinus, the breadth and thickness of the abacus, all that approaches rather the first group of edifices than the second. It is also easy to prove on the ground, that the temple of the Lacinian promontory presents in its plan this unusual extension in length with relation to the width, which is the most striking characteristic of the so called temple of Artemis, and in a lesser degree of temple C. It is stated t that in the 16 th century the temple was still almost intact and had 48 columns. Now this number is just that presented by temple C, due to the double row of its front portico. Consequently, to have the number of columns that was seen there before it furnished the materials for the episcopal palace of Cotrone, it is necessary for the temple of Hera to have likewise had 17 on each side, and that like the edifices to which we have compared it, those columns were closer on the lateral facades than on the front and rear facades, so that the abacuses of the capitals nearly touched.

"It results from these observations that the column of the temple of Hera Lacinia is the most ancient example of Grecian architecture that exists on the Italian continent. The d edifice of which it is the last remnant can only have been constructed at about the end of the 7 th or beginning of the 6 th centuries."

* So called temple of Lycian Apollo at Metaponte (Chiesa di Sansone). F. 6, C. 12 columns. Height of columns 13.4'.

Lower diameter of shaft 4.44'. 20 flutes. Dimensions of edifice with substructure, 136' × 73.8'. There were discovered in the ruins numerous fragments of terra cotta facings.

De Luynes and Debacq. Metaponte. Pls. 7-12. Lacava. Topografia e storia di Metaponte. Naples. 1891. Pls. 2-6. Sonte - Simone. Studi sugli avanzi di Metaponte. Bari. 1875.

Another temple of Metaponte (Tavola dei Palladini or Temtio delle colonne Paladine). There remain 10 columns on the left side and 5 on the right side. Probably F. 6, C. 12 columns. 20 flutes. Lower diameter of shaft 3.6'. Intercolumniations at the sides vary from 9.5 to 9.65'. The plan has not been entirely restored (Fig. 262); all that is known is, that the cella was divided into a naos (37' long) and an opisthodome (12.7'). The architrave no longer has its cornice; it must have been two courses in height. For the form of the c capital, there is not a perfect accord between the drawings of Debacq and those of Sonte-Simone.

Plates IX; XXIII,2,13,14; XXV,1; XLIX,8; L,10; Figs. 216, 220, 235.

De Luynes and Debacq. Metaponte, pls. 3-6. Sante Simone, Studi, etc.,pls. 1-4. Lacava, Topografia, pls. 8-10. Römische Mitt. Vol. VI. 1891. p. 363.

Temple of Demeter at Paestum. F. 6, C. 13 columns. 20 flutes. F. Internal columns, 8.61, 8.63, 8.62 .8.63, 8.61'. E E.A.C, 8.63' etc. The columns of the portico are very ancient. Beneath the echinus they have a gorge decorated by leaves. Opisthodome. No rear pronaos. The edifice was certainly built in the 6 th century, and appears to have been thoroughly restored much later. The entablature was then entirely rebuilt, except the lower part of the architrave. This architrave is in two courses; it has drops under the triglyphs, and it is separated from the frieze by a double moulding. I The triglyphs are formed of slabs inserted in the frieze. I This terminates at the angles with a part of a metope. The cornice is without mutules. The cornice has an abnormal projection. Its soffit is decorated by coffers that are repeated on the raking cornices of the pediment. These arrangements foreign to Grecian architecture permit one to recognize a restoration in the Roman period in the entire portion of the entablature above the lower course of the architrave.

The arrangement presented by the pronaos remains uncertain. The actual condition suggested to Lagardette and to Labrouste two very different restorations. Before the entrance of the cella are columns with 24 flutes and bases, whose capitals have not been found; it is not known to what order they belonged. It is possible that they date from the late restoration, and that the entire front portion of the building may have then received a new arrangement. In any case, there was never a rear pronaos.

Pls. XXVI,9-12; XLVII,14; XLVIII; XLIX,9; L,11; Figs. 210, 215, 223.

Temples at Selinonte. F. 6; C. 14 columns. F. Intercolumniations, 14.43, 14.63, 15.15, 14.63, 14.43'. E.A.C. 14.75, 15.1' etc. Cella very narrow. lateral porticos have nearly the width of those of the pseudodipteral. No rear pronaos. Metopes sculptured on the frieze of the facade.

Pls. XVI; XXIV,5,10,19,20; XXXVI; XXXVII; XXXVIII; XLI,6; XLVII,23; XLVIII; XLIX;10; Figs. 219, 228, 234.

Temple T at Selinonte. F. 8; C. 17 columns, according to Hittorf, 16 according to Courtepee. In the interior are two rows of 10 columns according to Hittorf, 9 according to Courtepee (Fig. 264). This temple is one of the largest that the ancients built, and may perhaps be regarded as pseudodipteral. Its wide porticos place at the service of the public an area of 27,960 sq. ft. The edifice measured with the substructore is 392' long by 175' wide. Pronaos enclosed by 3 columns on three sides. Rear pronaos. Construction dates from two epochs. The facade is the oldest part and is contemporaneous with temples C and D. The construction seems to have been interrupted, then resumed in the 5 th century, when temple R was built. Very marked differences distinguish the columns of the principal facade, of the lateral facades and of the pronaos from those of the rear facade anf of the rear pronaos.

Pls. XVII; XXXII,5-9; XLVII,11; XLVIII; XLIX,11; L,13; Figs. 232, 264.

So called temple of Poseidon at Paestum. Facade intercolumniations; 14.2; 14.64; 14.64; 14.64; 14.2'.

Sides; intercolumniations at angles 13.9'; others 14.25'. Number of columns of portico 6 × 11. Interior, 2 rows of 7

columns. This is the sole temple where still exist and are partly preserved the two orders superposed in the interior of the cella. A round hole of small depth indicates the places of the drops on the mutules.

The ceiling of the cella was at a higher level than that of the portico. There can be no doubt on that point; this results from the examination of the remaining parts of the edifice. One will later see in temples of the same arrangement, but of a later epoch, that the carpentry of the roof a and of the ceilings could form the same entirety; the proportions adopted have led to establish the ceiling between the tiebeams of the carpentry of the roof, and even rigorously all ceilings of the temple might have been at the same height. This is a hypothesis not beyond all probability; but as the temple of Paestum is the only one in which the internal colonnade remains, this conjecture can receive no direct confirmation. Besides, the system that we have adopted for the restoration of the carpentry of Paestum, may also have been applied to these less ancient temples; There is no improbability in assuming this. It is what we shall show later, particularly in relation to the temple of Zeus at Olympia. According to the restoration presented by the German architects, the cella, its floor being raised with regard to that of the portico, would be that of all parts of the temple having the least height.

Pls. V; VII,3; XIV; XXI,1; XXIV,7,9; XXVIII; XXIX; XXXII, 10; XXXIII,7-9; XXXIX,2; XLI,9; XL,3; XLVII,19; XLVIII; XLIX, 12; L,14; Figs. 156, 181, 185, 200, 205, 206, 208, 217, 225, 229, 231, 233, 24,, 246, 255.

So called temple of Hercules at Agrigente. The most ancient of the temples of Agrigente (Fig. 265); may have been built soon after the founding of the city (580). F. 6; C. 14 columns according to Cockerell, 15 according to Durm. 24 flutes. On the capital the profile of the echinus forms an angle of 45 degrees.

Entablature high and heavy. pronaos in front and rear. Cella narrow and long. Pls. XV; XLIX,13; L,15.

Houel, Voyage pittoresque. Vol. GV, pl. 218. Antiquities of Athens and other places in Greece. 1830, Pl. 9. (Cockerell) Serra di Falco. Vol. III, pls. 15-19. Hittorf. pl. 21,5.

Note 1.p.597. Names by which are designated the temples. 1, Zeus Polieus (in the midst of the structures of the modern city of Girgenti). 2, Demeter and Kore. Hera Lacinia. 4. Concord. 5. Hercules. 6. Asclepios. 7. Zeus Olympios. 8. Castor and Pollux. 9. Hephaestos.

Old temple of Athena on the Acropolis af Athens. F. 6; C, 12 columns. Intercolumniations, 12.25;15.15; 15.15; 15.15; 12.25'. 20 flutes. The building rests on a single step. Front and rear pronaos. The cella presents a very abnormal aerangement; it is divided in depth into three parts. First comes the naos properly so called, divided into thre aisles, Pl. XXX, C; it had one internal order. Behind are two rooms separated by a hall placed on the axis itself of the building (D and E). Beyond these chambers is an opisthodome, a large hall (F). The statue of the goddess was placed in the central aisle of the naos (C). The other rooms 'D, E, F) served as storerooms; until the completion of the Parthenon, they contained the treasures of Athena. This is the edifice known under the name of Hecatompedon in the 6 th and beginning of the 5 th centuries. Only the foundations remained at the time when the excavations were made, that laid bare the rock of the Acropolis. Some architectural members were found in place in those excavations; others had been again employed as materials in the enclosing walls of the Acropolis. The cornice was of marble; marble tiles covered the edifice.

To Dörpfeld is due the honor of having uncovered this edifice, and of having brought to light the important part that it played on the Acropolis of Pisistratus. The ideas that he has expressed on this subject have aroused enough controversy, that it is proper to give the list of the principal studies in which the questions have been discussed. There can be no doubts on but two points. Was the temple repaired and restored after the second Median war? Did it remain after the erection of the Erechtheum?

Dörpfeld, der alte Athena Tempel auf der Akropolis (Athen. Mitt. 1886, p. 337-351; 1887, p. 25-61, 190-211; 1890, p. 420-439; 1897, p. 159-178). E. Petersen in the same, 1887, p. 62-72. Ant. Denkm. I, pls. 1, 2. Penrose, Principles of Athenian Architecture. 1888. p. 5-6, pl. XLVI. Also see objection in an Article on the ancient Parthenon, Jour. Hell.

Studies. 1891, p. 291-296. E. Curtius accepts the ideas of Dörpfeld (Die Stadtgeschichte von Athen. 1891. p. 71-74).

Plates XIV; XIX; XLVII,4; XLVIII.

So called temple of Athena (?) at Syracuse, now cathedral of S. Maria. If this temple be partly preserved, this is because after the fall of paganism it was changed into a church There remain 22 columns still standing and supporting the architrave, 9 at the south and 12 at the north sides, 1 on the rear facade; they are engaged in the walls of the church. T The alterations required by this change of purpose no longer permit the establishment of the entire plan of the Greek edifice. F. 6, C. 14 or 15 columns. 20 flutes. The cella was long with a pronaos in antes. The columns are set close together; they sensibly diminish upward; the entasis is there scarcely noticed. The cornice has everywhere disappeared from the entablature. Where some parts of the frieze remain, the triglyphs are narrow.

Houel, Voy. Pitt. III, pls. 194, 195. Serra di Falco, IV, pls. 5-8. Cavallari-Holm, p. 176, 177; 382-384. Pl. L,6.

Temple of Apollo at Delphi. Built by the Alcmeonides between 538 and 515. As contractors, they were charged with the construction, in view of which and by collections made for 10 years in the entire Greek world and among the lovers of the Greeks, like Amasis, the council of the Amphictyons had gathered 300 talents, about $365,625. (Herodotus. II, 180). The architect was Spintharos of Corinth.(Pausanias, X, 5-13). The Bull. corr. Hell. (1896, p. 641-654) contains a note in which Homolle summarizes all that the recent excavations have informed the explorers concerning the construction, arrangement and ornamentation of the edifice; but this information is reduced to very little: the temple of the 6 th century appears to have been almost completely rebuilt in the 4 th century, either as the result of a fire, or rather after the earthquake, that destroyed the substructures. There remains from the primitive edifice very few remnants, which have been utilized as materials, either in the substructures of the new temple or in various fills.

The terrace works were executed before founding the temple and were veey important; one can compare them to those undertaken in the succeeding century on the south slope of the A

Acropolis in order to prepare the esplanade on which rose t the Parthenon. There remains of that effort the polygonal wall, a considerable monument (Fig. 151). Among the rare fragments that it is believed can be attributed to the temple of Spintharos are some of tufa and some of marble; thus is confirmed the statement of Herodotus, according to uhich t the Alcmeonides employed Parian for "the front part," doubtless that they were compelled to do so by their contract(V, 63). Men rarely employed marble until then except for sculpture; it was not without surprise and admiration that they saw the architect of the Alcmeonides use it in their construction; laborious efforts and heavy expenses were necessary to transport from Paros to Delphi all those blocks of marble.

By a series of calculations based on measuring the fragments of the few remaining triglyphs and metopes, it is believed that the dimensions of the temple were fixed in an entirely approximate manner. Measured on the stylobate, it was about 190 ft. long by 75.5 ft. wide, dimensions sensibly equal to those of the rebuilt temple. As to the internal arrangement, nothing could be known.

The columns were made of drums cut from fine and close grained tufa, that received inly a very this coating composed of several coats of milk of lime. These drums averaged 1.97 to 2.03 ft. high, had 20 flutes, and a diameter varying from 4.36 to 5.54'. A fragment of a capital was found, which permits a restoration of it. It frankly has the profile of the 6 th century, the high abacus, a very flat echinus with a strongly rounded edge. The architrave was in two courses in height. There were found two fragments in Parian marble of the fillet crowning it and that bore the drops. The lower c block has disappeared, those great blocks of marble having been recut for other purposes; but is has been found in tufa. Comparison of the marble fillet and the architrave of tufa gives for the total height of the architrave 4.36 ft. There is a piece of a triglyph of white marble; the height of this member must be 4.53 ft. By the examination of the mutules, one recognizes two types of triglyphs, one 2.72 and the other 2.95 ft. wide. The intercolumniations were not all equal. Two lions' heads, designed to serve as spouts, present characteristics of archaic art. From a fragment of a moulding that c

came from the tympanum, one can deduce the inclination of t the pediment. The ratio of height to length of it was 1:8.64. The covering was of marble in great flat slabs raised at the edges to facilitate the flow of the water and to receive the covers of the joints, that were made of the same material. A winged and flying Nike of white marble, several fragments of which have been collected, played the part of acroteria, as at Egina (Pl. VII, A).

On the evidence of Pausanias (X, 19-3), there were statues in the pediment; it is thought that the remains were found in the fragments of two series of figures, not wrought on the back, some of which are of marble and others of tufa, which accords with the statement of Herodotus. Euripides describes the groups seen by the chorus supposed to walk before the p principal front of the temple (Ion. Verses 190-219): "Observe," says the chorus, "the defeat of the giants on the stone wall." Did this refer to paintings that covered the walls of the c cell beneath the portico? To sculptured metopes? And if this description must be applied to metopes, are the metopes those of the portico below the pediment, or indeed the metopes of the frieze of the pronaos, that were decorated as on temple R at Selinonte? (Pl. XXXVII). It does not appear that the excavations furnished any element that permits the solution of this problem.

So called temple of Themis at Rhamnus. A small ante temple. The column has 5 1/2 diameters in height, and the profile of the capital is still flatter. Made of blocks of Pentelican marble, the wall of the cella is of polygonal masonry; at l least that part of the edifice appears to precede the Median wars. Very near this monument is found a peripteral temple of small dimensions, but entirely of marble, which is known under the name of temple of Nemesis (Pl. XV). Judging from the forms and proportions of its architecture, the latter edifice would be later than the Parthenon. It is probable that these two edifices were both consecrated to Nemesis; that the peripteral temple replaced the old chapel in the second half of the 5 th century. The sole reason for believing that Themis had a temple at Rhamnus is the fact, that the name of that goddess was found there engraved on the bases of statues, but Pausanias did not see the temple of Themis at Rhamnus, and it

seems probable from the text of the inscriptions, that Themis was honored there only as the "paredre" of Nemesis. (Ephemeris. 1391, p. 52, 53).

Temple of Athena at Ægina. Facade nith sensibly equal intercolumniations. F. 6, C. 12 columns. It is the only archaic temple within our knowledge, where the tympanum of the pediment was filled by figures in the round. It has retained important elements of the decoration of the roof; like the acroteria of the apex and of the angles of the pediment.

Pls. VII,A,B,C,8; XIV; XXI,9; XXVII,2-6; XL,16; XLII, 2,6, 7; XLIII; XLV; XLVII,5; XLVIII; XLIX,14; L,15; Figs. 169, 233, 254, 255.

Temple R at Selinonte. Date in the first half of the 5 th century; if we mention it here, it is because, that for what concerns the place assigned to sculpture in the decoration of the temple, that the arrangement of the columns of the portico with regard to the area of the cella, this temple has useful points for comparison.

F. 6, C. 15 columns. 20 flutes. F. Intercolumniations. 14.6; 15.25; 15.45; 15.25; 14.6ft. Small diminution of shaft. Front and rear pronaos. Opisthodome. Sculptured metopes on internal frieze of each pronaos; perhaps the most ancient example of that arrangement.

Pls. XV; XXI,5; XXXI; XXXII,14; XXXIII,1-5; XXXVII; XL,1; XLI,11,14; XLII,17; XLIV,1-4, 12,13; XLV; XLVII,27; XLIX,19; L,22. Fig. 231.

Temple of Segeste. This temple appears to belong to the second half of the 5 th century; but it has served us to show no far the pteroma was independent of the naos (p. 359). By this means it has found a place in this list. The edifice never having been finished, the columns of the pteroma are all standing and are without flutes. The capital also presents a very firm profile. The proportions of the entablature and of the pediment are very happy. Of the walls of the cella remain only some trecas of the foundations; it is a question if that cella was built (Fig. 266). F. Intercolucniations. 13.5; 13.73; 14.25; 13.73; 13.5 ft. C.&.A. 13.5; 13.73; 14.2; 14.3 ft. etc.

Plas. XXIX,3; XLI,1,2,3; XLII,14; XLVI,22; L,27; Figs. 180, 255.

* Temple of Apollo Pythios at Gortyna. This edifice merit mention, as the sole monument of religious architecture so far studied and recognized in Crete. According to the drawings of Halbherr, at the origin it was composed only of a great and nearly square hall, measuring 47.4 × 53.5 ft. in the clear. A door pierced in the eastern wall gave access to thi hall. All that can be said in regard to the date of that structure is, that et certainly preceded the first half of the 7 th century; on the walls of the cella are engraved inscriptions; according to Comparetti, the most ancient belong to the time between 650 and 600. What further gives that part of the edifice a character of high antiquity is, that there has been found at the right of the entrance sumps intended to receive libations, and which are called escharai. We have found these sumps in buildings of the Mycenaean age. The custom was retained in the course of the classical age in certain temples, such as that of the Cabiris at Samothrace, in Beotia, and the Asclepion of Athens (Histoire de l'Art. Vol. VI. p. 283, 284, 323, 343, 571; Vol. VII, p. 60, Note 2.

About the third century, to place the edifice in harmony with the taste of the time, a pronaos 19.7' deep was added to it, closed in front by a wall decorated by 6 engaged columns of the Doric style surmounted by a pediment. This pronaos was entered by a door opening opposite that of the naos.

Halbherr, Relazione sugli scavi del tempio d'Apollo Pythio in Gortyna, with illustrations in the text and five pls. (Mo Antich. Etc. Vol. I, 1889, p. 10-38).

Basilica or great portico of Paestum. In the study that we have made of the Doric column, we have had to take into account the peculiarities presented by the column and capita of that edifice, the oldest at Paestum; but we do not believe that it ever was a temple. (p. 560, Note 1). Thus in the Cha ter devoted to civil architecture, we shall give its plan, and shall seek to divine its purpose.

Pls. XXV,3; XXVI, 1-8; XXXII, 1-4; XLVII,12; XLVIII; L,31. Fig. 214.

Chapter IY. RELIGIOUS ARCHITECTURE.

The Ionic Style.

1. The General Arrangement of the Ionic Temple.

When the historian seeks to go back to the origins of the Ionic order and to follow it in its evolution, he does not dispose of the same resources as for the Doric order. Time has not [redacted] spared for his benefit an edifice, from which he c can expect revelations having the importance of those availing him from the excavation of the temple of Hera at Olympia. Nowhere in the entire extent of the ground that he proposes to explore does he find a monument, that renders it the service of being in some sort present at the birth of a style, and of an entire system of art. The primitive type escapes his researches; the starting point is lacking for him, and he is no longer able to reestablish the entire series of s successive creations of this architecture. Yet this produced in Asia Minor and the adjacent islands, edifices of very great dimensions and richly decorated, such as the first temple of Artemis at Ephesus and the temple of Hera at Samos. I There exist notable remains of those buildings; if the ruins had been uncovered by systematic excavations, one would know the arrangement and appearance of the edifices, that the Ionian race built in its days of power and glory. This satisfaction was not afforded to archaeologists, and for Ephesus at least, they must renounce it forever. The excavations of Wood were executed from 1863 to 1870, and were as badly directed as expensive; scarcely in uncovering enormous masses of rubbish, have they ended by uncovering some of the arrangements of the second temple, that constructed under the successors of Alexander. As for the old temple, that destroyed by the torch of Erostrates, Wood has reported curious fragments; but no effort was made to restore its plan, when with more experience and care, he might perhaps have followed the main lines among the foundations of the later edifice. It is now too late; the ground has been thoroughly overturned; it would be wasted labor to seek features that the pick of the excavator has confused and effaced at his pleasure.

It is otherwise at Samos. There remain 12 drums and one column, and although the positions of some have been disturbed they yet stand in place; the lower part of the capital that

surmounted it, has been recorded in the rubbish beside it. Most of the bases of the colonnade and the pavement are still in place, concealed under the vines that cover the area formerly occupied by the cella and the portico.[1] This is proved by some pits dug in haste; but the excavations were not sufficiently deep or extensive enough, for one to know at p present with relation to the whole, the part played by those elements of the arrangement appearing at the bottom of the trenches. The partial reports offered lead to several interpretations; the temple indeed seems to have been peripteral dipteral with 8 columns in front;[2] but it is impossible to restore with some certainty the plan of this vast edifice on such incomplete data.

Note 1.p.604. On the ruins of the Heraion, see Tournefort, Relation d'un voyage du Levant. 1717. Vol. I, p.420-422.

R. Pococke. A description of the East. 1745. Vol. II, p. 28, 42.

Choiseul-Gouffier. Voyage pittoresque de la Grece. 1782. Vol. I. p. 100 and pl. LIV (the plan contained that plate is that of Pococke).

Antiquities of Ionia. 1821. p.64-67. Pls. II, III, IV, V, VI and Chap. V.

J. Giraud. L'Heraion de Samos (Bull. Corr. Hell. 1880. p. 373-394 and pl. XII) with a partial plan.

Dörpfeld. The same. p. 261-270.

Note 2.p.604. Dörpfeld informs me that K. Humann made excavations at Samos, in the course of which he recovered the p positions of 8 columns of the facade. The plan on which he placed them existed among the papers of the late architect Strack, at whose account the works were executed.

In the ruins of Neandria, a little city of Eolia on the Tchidri-d.gh, not far from the site where was to rise later Alexandria Troas, was recently discovered an edifice of the Ionic style, which would date from the 7 th century, according to the learned architect making the excavations.[1] This edifice is composed of a simple cella resting on substructures projecting at the four sides. It had neither pronaos nor opisthodome; a row of columns divided the interior into two aisles of sensibly equal width (Pl. LI); the threshold was at the level of the ground around it; thus no stylobate or

steps facilitated access to the interior. Was there an external colonnade? Men are not in accord on that subject. Koldewey denies the existence of this colonnade;[2] Dörpfeld would incline to admit it after the examination, that he made of the state of the place and of the fragments recovered; he would believe in a portico, whose supports were very near the wall of the cella.[3] We reproduce the restored plan, that he has courteously communicated to us below the plan of Koldewey (Pl. LI). There is another point on which a question can be asked. Is it certain that this edifice was a temple? No doubt in that respect, if one adopts the restoration of Dörpfeld. Some uncertainty would be permitted with that of Koldewey. By its internal arrangement, the edifice would recall the markets of Assos, Pergamos and Athens, as well as the naval arsenal of the last city. Yet it is to be noted t that in the spacious halls that served for covered markets, the entrance nas nearly always on one of the longer sides, while it here appears to be found on one of the facades. Further, the same arrangment is found in another Ionic edifice, whose religious purpose cannot be disputed, in the old temple of Locres, and perhaps it is necessary to see in this division of the cella into two similar aisles, one of the oldest arrangements of the Ionic temple, an arrangement that after having been tried in various places, was abandoned early, f for the inconveniences that it presented.[4] On entering the temple, one ran against a column that barred the passage and view; the colonnade concealed the statue placed at the back of the sanctuary, or compelled the placing of two statues, one in each aisle. Then we believe that a temple must be r recognized in the muilding of Neandria; but we are not decided as to the true character of the plan, and the edifice is further of small dimensions. It is not that sort of a chapel, that will permit us to restore the type, that under other c conditions, Ephesus and Samos might have shown us, that of the great entireties created by the art of Ionia at the time of its full development.

Note 1.p.605. Neandria. 51e Program zum Winckelmannsfeste der archaeologischen Gesellschaft in Berlin, by Robert Koldewey. 49 pp, 1 map and ills. in the text. Berlin. 1891.

Note 2.p.605. The same. p. 30-31.

Note 3.p.605. Letter of Dörpfeld of Oct. 13, 1895.

Note 4.p.605. Koldewey. Neandria. p. 44-45.

These entireties being destroyed or still buried in the e earth, it is necessary for us to cross the Egean sea and come down to the Attic temples of the 5 th century to meet with edifices of the Ionic style, whose plans are clearly read on the ground, and whose structure exists in full or in part. These monuments are still for the new order, thus that best give us the idea of methods that must have been taken from the beginning by the architects, whose works offer the first models of this art and founded its traditions. It is for that reason that we have now presented the plans of the Erechtheum, of the temple of the Wingless Victory, and of a temple now destroyed, that was still seen in the last century on the o banks of the Illissos (Pl. LII).[1] If suffices to glance at it to show that these plans present very curious peculiarities.

Note 1.p.606. The plan of the temple of Illissos is borrowed from Stuart. Antiqs. of Athense I. p.27-31, pl. VII.

Of these three edifices, the Erechtheum was most important; then to it will be chiefly devoted the examination. At first, one notes that there the internal area comprised between the walls does not have the proportions of the Doric cella; it is not narrow and deep like that; it is short and wide. The wall of the facade is pierced by a doorway, but that is not the principal doorway. In the lateral walls open two doorways, one of which on the north being that, whose rich decoration is so generally admired. Thus the sanctuary is accessible on three sides, while in the Doric temple, there was only one entrance, the simple opening that connected the naos and its vestibule, the pronaos with its two columns and two antes. Here is no pronaos. The doorways open directly on t the porticos, for at the Erechtheum is no continuous colonnade surrounding the entire edifice. What replaces this colonnade is three portocos, each differing from the two others in arrangement as well as by the height and form of its supports. Before the principal facade 6 columns stand in a row; on the opposite facade are 4 half columns attached to the wall; there are again 6 columns at the northwest angle, w with only 4 in front; at the south is the famous porch of t the cariatides, where are no longer fluted shafts, but stat-

statues of noble and proud canephores, charged with supporting the weight of the entablature.

The analytic study of this complicated plan alone sufficiently emphasizes one of the characteristics, by which the I Ionic temple is defined at its origin. It does not have the austere simplicity of the Doric temple; it was not born like that with fixed forms, forever determined by the imitation of the Mycenaean megaron; it was not born with that beautiful girdle of columns, that the architect clasped around the sides of his edifice, when from the royal house he made the august dwelling of the immortal gods. In the entire arrangement of the various parts composing it, the Ionic temple has something looser, more irregular and more capricious; it comprises additions and varied appendages, for which if the architect had attempted, he cannot have found an appropriate place in the Doric temple.

However small the edifice, the plan of the temple of Wingless Victory is no less significant; the original character of the Ionic temple is no less clearly marked there. We find there the arrangement termed amphiprostyle, the temple with four columns on each front and rear facade. As for the cella, it is nearly square.

The temple on the Illissos is also amphiprostyle; but the plan there approaches more nearly to that familiar to us. As in the Doric temple, the cella is preceded by a pronaos with walls terminated by antes. With that edifice is seen to commence a movement of assimilation henceforth pursued without interruption under the victorious ascendant of the Doric style and for its benefit. The arrangements suitable for the Doric temple were gradually imposed on the Ionic temple. It became peripteral; it had its pronaos and opisthodome. Henceforth the edifices belonging to either order were only distinguished by the type of the supports, by the composition of mouldings of the entablature. After the 4 th century is scarcely anything of Ionic in the temple bearing that name, but the column with the special form characterizing it, and the frieze with its continuous treatment, where is wanting the rhythm of the triglyphs. This is what we desired to demonstrate, when on the same plate and opposite the temple of Neandria and the temples of the Acropolis, we have represen-

represented the temple of Athena at Priene, one of the most elaborate works of the architects of the Hellenistic period. (Pl. LIV). By consulting only its plan, one cannot tell to what order the edifice belongs; this plan is that of the Doric temples of Sunium, Rhamnus and Nemea (Pl. XV). As men aim more at luxury and effect, they will multiply the number of columns; these will be doubled on the sides and on the principal facades; but the type will no less remain the same always, a copy of the Doric type, for that is the general arrangement.

To judge of it by the Attic types, where the architect seems to have remained faithful to the spirit of Ionian archaism, what on the soil of Asian Greece and of the adjacent islands constituted the Ionic temple in the most ancient times, would have been a naos of moderate size; if one must believe Koldewey, there was nothing else on Neandria. Porticos can be applied against all or a part of the wall of that cella to vary its appearance and decorate the entrance; but these porticos were never more than frontispieces, to which the caprice of the constructor assigned one place rather than another, according to the case. No absolute law controlled the arrangement of the supports in the external additions; no rule like that of 6 columns for the facade determined the number. The temple increased with the importance of the cities that erected it and with progress made in the art of building; but Ionic arrangements no less continued to retain freer charms than those of the Doric order. They did not even depart from it when the Athens of Pericles decided to ornament its renewed and restored Acropolis by Ionic monuments; how would one explain otherwise what the charming grace of those light edifices has of the unexpected and even irrational? It was only in the course of the succeeding century, that Ionic art ended by renouncing this freedom. The ancient dialects of the Grecian idiom, formerly separated by such decided differences, tended to disappear; everywhere men commenced to speak and especially to write the same language, that which is termed the common language. A phenomenon of the same kind was then produced in the domains of sculpture; if the dialects of the art did not come to be confused, that preserved the precision of the forms that they impressed on the ma-

material, at least all that approached each other and interpreted each other. By this cause they lost something of their vitality. The Doric style was then almost abandoned for the benefit of its rival; but before falling into desuetude, it faded to Ionic, of one can so speak. As practised by the architects of the Macedonian age, that is no longer more th than a sort of eclectic compromise between the two systems, formerly so profoundly original, that were born in different surroundings, and nere each developed in its own way with entire independence for several centuries.

Even when there is accomplished this sort of fusion, the Ionic allows its arrangements to occupy more space and be m more complex, than the Doric arrangemen.s; it contracts them less; it freely multiplies there the supports; it enlarges the intervals that elsewhere remain narrower. It is only when one finds in it the type known under the name of dipteral ((Pl. XXX,13), and if we have found in the Doric temples of Sicily (Pl. XVII) a certain plan, that approaches that of t the pseudodipteral (Pl. XXX,12), in the Ionic temples alone has that arrangement been fully realized, such as Vitruvius defined it. Finally, the Ionic alone extended the number of columns on the facade to 10 or 12; only it with its derivative, the Corinthian, furnishes examples of the decastyle and of the dodecastyle temple.[1]

Note 1.p.610. One finds for citing in the Doric style only one example of an arrangement of this kind; this is the dodecastyle portico that Philon added to the great hall of initiations at Eleusis; but that portico is of juite late date (311), and is otherwise only a sort of facing. The hall of initiations was not a temple, properly speaking.

Before beginning the study of the forms of the Ionic order and of the elevations that they form, it is proper, as we have done for the Doric order, to define the Figs. that we have grouped on the Plate, which is intended to give an idea of the general character of the Ionic order.

Explanation of Plate X.

A to E, architectural members of the ancient temple of Ephesus. A, B, base and lower part of the shaft of the column. C, capital of the same column in elevation. D, side elevation of the capital. E, plan of the capital. After large scale drawings communicated to us by M. A. S. Murray. Reductions

from these drawings were given at the close of his Article; The sculptured columns of the temple of Diana at Ephesus, in Jour. Roy. Inst. Brit. Architects. Vol. III, No. 2.

I. Angular and perspective view of the temple of Wingless Victory, restored after the drawing of Landron(Voyage archaeologique de Le Bas. Architecture. Athens. Pls. 2 to 8.

II. Coffers of the ceiling of the same temple(The same, pl.4

III. Entablature with architrave of a rock-cut tomb at Telmissos. Architrave with two facias. Cornice with modillions. Perspective view after geometrical drawings of Texier. Description de l'Asie mineure, Pl. 171.

IV. Entablature of temple of Athena Polias at Priene. Perspective after geometrical drawings of Thomas. (Rayet & Thomas. Milet et le golfe Latmique. 1877; pl. 13). Architrave with 3 fascias. Cornice without modillions.

V. Entablature of Erectheum. Architrave with 3 fascias. Cornice without modillions.

VI. Roofing tiles of the temple of Neandria. Perspective after Figs. 66, 67, of Koldewey. Neandria.

2. The Columns.

What is first striking on the Ionic edifice, even on that where is most marked the effect of influences slowly acting, is the character of the column. Everywhere, as well on the colossal temples built under the Seleucides and under the Romans, as on those old and venerable edifices on whose plinths are read the names of the half legendary kings of Lydia, the Ionic column always with a bearing and appearance that distinguish it from the Doric column at the first view. Three traits especially contribute to give it that very peculiar appearance; it always rests on a base; its shaft is more slender than that of the Doric column, and is dimensioned less; those beautiful curves termed volutes never fail to ornament the capital; finally, the upper surface of that is always rectangular, while on the Doric order that surface is always square, which changes the mode of harmonizing the top of the shaft with the capital.

One is accustomed to present as the most excellent type of the Ionic column, that of the Attic monuments of the 5 th century. Doubtless among all the columns that belong to that order, there is none that satisfies the artist as well as t

that of the Propyleum or of the Erechtheum, that has such a happy proportion, offers such pure lines, and whose capital is so elegantly ornamented; but the art that it represents did not succeed at the first stroke in producing this masterpiece. This was preceded by numerous experiments, each of which has rendered service, either by the advance that it marked beyond previous creations, or by its defects themselves, soon perceived anf corrected by a taste always on the watch. Of these preliminary sketches, most have perished; yet recently have been found a certain number, that have presented forms, whose strange variety has not failed to cause surprise. In current opinion, one of the distinctive characteristics of the Ionic column is the section of its flutes, which are not tangent to each other as on the Doric column; but are separated by a narrow fillet (Fig. 267); this is not the form presented by the flutes on the most ancient Ionic columns; they are similar there to the Doric flutes. Elswhere the shaft remained smooth. It is the same for the base; according to the edifices, it presents very different profiles. As for the volutes, how much time and experiment have been necessary for them to learn to regulate the design and make the connection! There is the only one method to follow if one desires to form an idea of the gradual formation of the type; that is to study it in its different states, as the engravers say, i.e., in all the monuments of the archaic epoch from which remain fragments that permit its column to be restored, either entirely or in part. One sometimes has the capital without the base, or the base without the capital; but even then, the attentive examination of that one of the elements of that entirety, which has not perished allows still a safe inference.

The most ancient column of a temple that can be restored in its integrity is that of the old temple of Ephesus, which was built about 560 with the aid of Croesus, as Herodotus relates, an assertion confirmed by the remains of an inscription engraved on one of the bases.[1] This advantage is due to the intelligent zeal of A. Murray, the curator of the Greco-Roman department of the British Museum; to appreciate at their just value the patience anf sagacity displayed by Murray in that difficult work, it was necessary to have seen in the

itself ten years since, in the storerooms the remains of the first temple that Wood had brought; I should have believed it impossible ever to utilize them. Pliny mentions as one of the peculiarities that distinguished the second temple of Ephesus, the fact that 36 of its columns were "sculptured",[2] a statement that has greatly embarrassed the commentators, until the time when Wood's excavations brought to light beautiful fragments of the reliefs in a grand style, which ornamented the lower drum of the columns in question. One would have thought that the idea of this unusual decoration properly belonged to Chesiphron and Metagenes, the architects of the second temple, and he would have attempted to explain it by the taste of the Macedonian age, by their desire of innovation at any cost, and by the pleasure found in the picturesque effect. However plausible that explanation might appear, it must be renounced. When the Ephesians undertook to repair the disaster caused by the folly of Erostratos, by the aid of subscriptions collected throughout all Greece, they certainly proposed to give to the new edifice a grandeur and magnificence that its predecessor could not have had; but they adhered to the reproduction of its principal arrangements, particularly of those forming its originality. That results from the study of the fragments of the first temple piece by piece, Murray restored a relief with figures; a young man and young women in long vestments, marched as in procession around a cylindrical shaft, that can only be the drum of a column; he had further recovered and fitted to the shaft a bit of moulding that surmounted this relief, and separated it from the upper part of the support. Then one can no longer doubt that the archaic temple also had its sculptured columns, besides more simple columns. Were they in the same number as on the later edifice? No one knows; but they must have been much admired in their time, on account of the happy peculiarity of their ornamentation.

Note 1.p.612. Herodotus. I, 92. Histoire de l'Art. V, 903.

Note 2.p.612. Pliny. H. N. XXXVI, 95. Pliny adds two words after (sculptured", which the manuscripts give as "una scopa" But these words do not make sense. It has been proposed to read "una a scopa," (one to scopa), and this correction had been accepted by all editors; these seem to have forgotten

that the celebrated sculptor of the Mausoleum had died long before the rebuilding of the temple was commenced. One only lends to the wealthy, says the proverb; this was to attribute to Pliny an error in chronology, that would perhaps exceed the measure of the negligence and contempt to which he is a accustomed. Murray suggests another correction, that varies slightly more from the text of the manuscript, but which has the merit of giving a veey satisfactory text:- "imo scapo," on the base of the shaft.

Murray devoted himself to the reconstruction of one of those sculptored columns. Only little bits and thin pieces of each member of that whole were found; but some of those bits presented surfaces that fitted and permitted them to be joined; thus one had the profiles of the mouldings, the places and movement of the figures, the curves of the volute. In comparison with what was lacking, he possessed little;yet there was enough to guarantee the accuracy of all done in the work of restoration; not an element of any importance w was introduced arbitrarily and by mere hypothesis.

Judging from the fragments remaining, it does not seem t that on the old temple all the bases were exactly similar; there were slight differences between them, according to the places occupied.[1] What was chosen here as a support for the column is formed of two scotias separated by astragals and a great torus (Pl. X, A). The torus is fluted horizontally. Above this base, separated from it by a round and by a high band forming a plinth, rises the first drum of the shaft around which extends the circle of figures symetrically arranged and marching with timed steps (B). This drum of exceptional character has its crown, a projecting ring, whose profile is a reversed ogee decorated by a collar of descending lanceolate leaves, separated by the ornament termed spear head. Above is a smooth round from which commences the column, properly speaking. Like that of Samos, its contemporary, it must be very slender; but there are only two or three fragments of it; one is therefore not in position to determine its height. What one is able to prove is, that the shaft had 44 flutes, that touch at their edges as on the Doric column. Yet there is a difference. Take a drum whose diameter equals that of a Doric column with 16 or 24 flutes, and propose to

insert 44 or more on that perimeter whose length is the same as that of the first; you must make them smaller to find room for them. The closer together they are, the edges will make the column appear weaker than if the edges were farther apart. In the classical arrangement, by the semicircular form given to the section of the flutes and the insertion of the fillets, one will obtain sharp edges, and thus he succeeds in recovering that strength of the lines of shadow, which the multiplication of channels tends to reduce.

The capital rests on an astragal, a sort of projecting bead decorated by pearls, which plays here the part if the concave bands of the Doric order; above a row of eggs.separate two volutes that join at top by a channec, whose lower edge describes a slightly rounded curve (C E). Where this meets the volutes, two little palmatiums mask the point of junction a and fill the angle by projecting above the eggs. This has c been named sometimes the ear of the volute, as one terms the eye the centre of the spiral, the point where its last scroll stops. Analogies easily seen suggested the use of these terms. The two volutes extend entirely beyond the line forming the prolongation of the shaft. The inner face of the scroll does not cross that line, an arrangement that gives to the top a width that seems rather excessive. On these sides the capital presents the form of the cushion grooved by scotias analogous to those of the base, but grouped here in the vertical sense.

We likewise possess most of the elements of the column of Samos. There had existed at Samos a very ancient temple of Hera; the bases of its columns were found beneath those of the edifices whose ruins exist.[1] The rebuilding must have occurred at the time of the great prosperity of Samos, under Polycrates (532-521).[2] According to the character of the forms, the column of Samos seems later than that of Ephesus. Thus its base is a more happy arrangement that approaches more the classical type (Fig. 268). It consists of two principal members; a high scotia and above it is a torus somewhat lower. These two mouldings are ornamented by very numerous horizontal grooves. Fig. 269 represents another base with sensibly the same profile, but which differs from the first in that it terminates in a sort of inclined plinth, that ser-

serves as intermediary between the base and shaft. Fig. 270 gives the profile of the same bases after another drawing. This must be that of a column of the second row. As for the shaft, it was smooth (Fig. 271); this is shown by the column still standing in part, with numerous drums lying on the ground. As the flutes are wanting here, is that because the e edifice was not completed! One can scarcely believe this, when he recalls how rich and powerful Samos was in the 6 th century; there are other examples of ancient Ionic columns on which the flutes are lacking.

Note 1.p.615. Girard. Bulletin. 1880. p. 389.

Note 2.p.615. At the end of the tale of the adventures of Polycrates, Herodotus (III, 160) mentions the three great works that he admired at Samos. The temple of Hera (f II, 148), the dike of the port and the tunnel of Eupalinos cut beneath the mountain to give good water to the city. The temple must be one of those mentioned by Aristotle as an example of the great works, that the tyrants undertook to divert the people and cause them to forget their subjection. (Politics. V, II). On the tunnel of Eupalinos, see Fabricius, Altertümer auf der Insel Samos (Athen. Mitt. Vol. IX. p. 163-197, pls. 7, 8).

Note 1.p.617. The fragments of a volute gathered on this site and drawn do not appear to have belonged to the order that we are studying; they came from a much smaller building than that of our column. (Antiq. of Ionia. 2821. Chap. V. Pl. IV, 5).

The column was very slender. It doubtless lacks the upper part, but the lower diameter of the capital exists in a fragment found on the ground near the base, and on the 12 drums remaining in place, one can measure the gradual diminution of the shaft. From the top of the base to the beginning of the echinus this shaft had a height of 43.33 ft., nearly 8 diameters. The capital was composed of two pieces joined by superposition, as indicated by the hole cut to receive a dowel in the top of the echinus, the only part of the capital remaining (Fig. 272). That echinus having eggs on its entire perimeter, it results from this that the volutes must have been cut in a slab with upper part enlarged; they fall at both sides of the echinus without having any connection with

that.[1] There is reason to believe that they presented an arrangement analogous to what we found at Ephesus, but what remains od the capital of Samos suffices to prove that it had its originality. It exhibits a peculiarity not found at Ephesus. This is that we meet with the necking for the first t time, which we shall find again in the capital of the Erechtheum; it is bordered by two fillets at Samos.

To an edifice of much less importance, the temple of Apollo Napea in the island of Lesbos, that a column belonged, which although of small height, no less merits attention. Napea w was a small city, whose ruins have been recognized in the construction of a church dedicated to S. Taxiarchis.[2] According to all appearance, this column is more ancient than that of Samos and even that of Ephesus; all its members have been found; it may be almost entirely restored. The base is made of a great torus surmounted by a round (Lig. 273); the shaft is smooth (Fig. 274); but what is most singular is the capital (Pl. LII, 1).[3] The volutes are tangent at their springing; they rise vertically and the centre is outside the line of the shaft. At top is left between them a space filled and d decorated by a palmatium. The top of the capital presents a smooth surface; it is a rectangular slab having the diameter of the column as its width (1.57 ft..); the length is 2.89 ft. The whole is cut in a block of trachyte 4.46 ft. long; it presents the same design on both faces.

Note 2.p.617. Koldewey. Die antike Baureste der Insel Lesbos. 90 pp., ills. in text, 29 pls. and 2 maps. 1890.

Note 3.p.617. Pl. LII. 1; capital from the temple of Apollo Napea in perspective, after the geometrical drawing of Koldewey, Pl. XVI. 2; capital from Neandria, after the geometrical drawing of Koldewey. Neandria. Figs. 60, 61, 62. 3, 4; column from the most ancient temple of Apollo at Naucratis. From the geometrical drawing of F. Petrie. Naucratis. Part I, Pl. III. 5, 8; the second temple of Locres, after Dörpfeld. Röm. Mitt. 1890. 5; the base and bottom of the shaft. 6; profile of the same parts. 7; fragment of the volute. 8; fragment of the c capital.(Figs. 4, 7, 13, 14 of the description.

The column of Neandria is also entirely known to us. There has not been found the least trace of base, for one cannot thus term the blocks of stone sunk in the depth of an area

of tamped earth and on which rested the lower drum of the s shaft. The base that we have everywhere seen very developed in the oldest Ionic columns, was entirely wanting here.[1] There was something singular in that peculiarity, really unexpected. As for the shaft, it was smooth with a very marked diminution. Nearly all the drums have disappeared. After having been ruined by a fire, that one divines from the charcoal scattered over the ground, the edifice served as a quarry for the adjacent villages. The blocks that form the capitals for the most part have been recut in place, the projecting parts and ornaments in relief were broken off; these have remained lying on the ground. One of the best preserved pieces is that discovered in 1882 during a visit paid to the Tchidridagh by Clarke, an American architect, then occupied with the excavations of Assos (Fig. 275).[2] One of the two r volutes is complete. The motive being symmetrical, it is easy to restore the missing portion.

Note 1.p.618. Koldewey. Neandria. p. 32.

Note 2.p.618. Clarke. A protoionic capital from the site of Neandria, in Papers of the Archaeol. Inst. of America. 1 1886. And in Am. Jour. of Archaeology. II, 1886, p 1-20, 138-145. To preserve that fragment from destruction, Clarke deposited it in the farmhouse of Calvert at Aktche-Keui (Thymbra), whose hospitality has left grateful memories in all travelers, who have passed over the Troad in the second half of this ((19 th) century. Dörpfeld photographed it there, to whose c courtesy we owe this proof.

Neither European nor Asian Greece had ever produced anything similar. All that can be compared with it are certain c capitals represented on painted vases;[1] also some funerary steles found in Cyprus;[2] but other elements intervene there, and the capital was constructed on a rectangular plan. The capital of Neandria was the first where that arrangement was employed for a column, playing the part of a support in a building. This type then surprises and interests. By the elements composing it, it recalls the Ionic capital; it is distinguished from that by the manner in which the elements are grouped there; one finds there both a correspondence and a difference.

Note 1.p.621. Gerhardt. Auserlesene griechische Vasenbilder.

Pls. 108, 185, 241, 242.

Note 2.p.621. Histoire de l'Art. vol. III, Figs. 51,52,152.

Soon after the capital of Neandria had been mentioned, that of Napea was uncovered; that arrangement has been found more recently in a capital found at another point on the island of Lesbos, in the acropolis of Mitylene (Fig. 276).[3] In these three pieces is the same direction of the volutes, the same palmatium interposed between the two elements of the couple. The type is everywhere the same; there are only variations without importance between the two examples. Thus at Napea the eye of the volute is indicated by a round hole sunk in the blackish tufa, in which was perhaps inserted a stone of lighter color; at Neandria and at Mitylene, a round passes through the block. What is peculiar to the capital of Neandria is, that the terminal area is smaller than elsewhere. It is only 1.31 ft. long; this is very small in comparison to the total length of the block, which is 3.94 ft. The reason of this arrangement is easily seen; its object was to prevent all contact of the volutes and the beams supported by the capitals.

Note 3.p.621. All our thanks are due to M. Paton, who was willing to communicate to us this fragment by the intermediary of M. Salomon Reinach.

As on the two capitals of Lesbos, at Neandria on the lower face of the block is seen the hole in which fitted the dowel, that connected this piece to the shaft.

When Clarke made known the fragment that he had discovered on the site of Neandria, he had no doubt that these two volutes were connected to the shaft by some transition, fillets or astragal, and by themselves composed the entire capital. At the end of the excavations that he made on the site of the ancient city, Koldewey arrived at an entirely different conclusion. He found on the site of the temple many leaves cut on the pieces of volcanic stone, liparite, of which were made the drums and the volutes. The ends of these leaves had been detached by the chisel from the block of cylindrical form of the surface of which their contour fitted. By comparing and adjusting together all these fragments, Koldewey soon found the places and restored the profiles of the architectural member, of which they were the fragments. Two col-

collars of falling leaves set on a part of the quarter round and enclosed between narrow rings decorated the top of the shaft. Between these collars and their fillets were differences in details between the columns, but the entirety of the arrangement was everywhere the same. The motive recalled that of the lower portion of the capital of the column of Persepolis.[1] Now on that the volutes are superposed on a doubled motive in which is believed to be recognized the imitation of a plant form, the terminal leaves of the date palm, s some erect and others hanging against the trunk.[1] Why was n not the same on the capital of Neandria? What confirmed Koldewey in the conjecture suggested by that analogy was the m manner in which he understood the plan of the edifice; according to him there were no supports in the temple other than the 7 columns that divided the cella into two aisles, and t that supported its roof. Volutes and collars of leaves can then only be the conjugate elements of the same capital, the leaves serving to make a suitable transition from the nudity of the very slender shaft and the ample expansion of these wide volutes. Thus Koldewey was led to restore this capital as we reproduce it in perspective after one of the three examples that he presents (Pl. LII,2). We have dispensed with indicating in this drawing the fractures, he had to join in order to restore that entirety.

Note 1.p.622. Histoire de l'Art. Vol. V. Figs. 312-317.

Note 1.p.623. The same. Vol. V. Fig. 492.

However interesting may be this composite type, it also r retains a hypothetical character in a certain measure. Nowhere, neither at Neandria nor at Lesbos, has the block on which are cut the volutes been found in place set on a drum surrounded by leaves. So far as we know, there have not been collected fragments of those leaves at Lesbos near the pairs of abutting volutes. One further has the proof on certain archaic columns, that volutes strongly resembling those of Neandria and whose projection is as great, were set directly on the shaft with a simple astragal near the junction. (Pl. LIII,1).[2] Yet the hypothesis is imposed, if it be demonstrated that all the fragments of Neandria, leaves and volutes, belonged to one and the same order, that of the cella. But this is just what is called in question by another very com-

competent observer Dörpfeld, who inclines to believe that the temple was peritperal. According to him, there were two different orders in the temple of Neandria, and consequently two different types of capitals. The capital of the internal order was formed by the double collar of leaves, that which he places above the other is the highest and widest of the two, whose leaves are rounded and ascending at their lower part to allow their points to hang freely toward the ground, while in the lower part the same leaves are shorter and are attached to the shaft (Fig. 277). The superposition of these two crowns so placed formed a capital, although very simple, which has a very happy effect with its unique motive, that is repeated while diversified, and with the expansion of the upper part. This capital would have been that of the columns of the cella. Did the blocks in which were cut the abutting volutes belong to the columns of the external portico?

Note 2.p.523. Pl. LIII. 1; capital from Delos, perspective after geometrical drawings of Nenot. 2; plan of the same capital from the same. 3; capital from Delos after the same. 4; capital from the Acropolis of Athens, perspective after drawings of Borrmann. Ant. Denk. I, pl. 18. 5; capital from the Acropolis of Athens, persepctive from the same. Ant. Denk. I, pl. 29.

Here are the reasons that seem to justify this mode of seeing. On one face of the block the volutes are traced very summarily. On the other the chisel has carried the work as far as possible. Hollows and reliefs have been executed with final precision. Nothing more natural than this dissimilarity between the two faces, if one admits that the columns terminated by these capitals were placed in the gallery. There only one face of the capital was visible, that turned to the exterior; the motive can be left without inconvenience as o blocked out on the opposite face. It was entirely otherwise in the sanctuary itself, where one passed between the columns. There a cylindrical capital with the same appearance wherever the spectator stood, was more in place. In a small city of Aegae in Eolia has been found a capital, that is only a replica of that of Neandria;[1] all the difference is that in the capital of Neandria the crown of foliage is single instead of being double (Fig. 278). This order belonged to one of the

halls of the public market of the city. That edifice can scarcely be earlier than the 3 rd century B.C.; one has noted a sensible analogy between the buildings of Aegae and those that the Altalides built at Pergamon. At about that time, Aegae depended on Pergamon.[2]

Note 1.p.624. One may ask how the architect solved the problem of the capital of the angle column. Had he doubled there the pair of volutes, as Ionic art did later? The fragments discovered give no indication on that point.

Note 2.p.624. R. Bohn. Altertümer von Aegae, unter Mitwirkung von C. Schuchardt. 75 illustrations. 1889. (Second supplement of Jahrb.). p. 31-32, 65.

Another observation supports this hypothesis. In these cylinders, around which extends the double crown of leaves, Koldewey believes is recognized the lower part of the capital; if they had really fulfilled that function, they would have been connected by a dowel to the blocks on which were carved the volutes. Now as Dörpfeld attests, they do not present on their tops the least trace of such a fastening. The architrave rests on the capital without any intervening fastening to connect and maintain in place these two members.

The problem set by the discoveries made at Neandria has then received two contradictory solutions, between which we can not choose with full certainty, having not been present at the excavations and not having seen the monuments. Each one has its difficulties; in favor of each can be invoked special arguments. The capital entirely of leaves as Dörpfeld assumes, would return to the category of those basket capitals with leaves, whose tradition is preserved in even that part of Greece. On the other hand, it must be confessed and not without regret, that we should renounce the admission of that complex type that Koldewey presents as having been that of the capital of Neandria. This type is not alone curious by its singularity. The forms there found together combine without effort; the entirety with a certain archaic air that has its charm, does not lack richness and amplitude. Finally, what completes the giving of a high value to this capital is the striking resemblance, that it presents of those of the royal edifices of Persia and of Susiana. Except the bulls, which properly belong to oriental art, one will find here

the same elements as there distributed in the same order. T The monuments of the Achaemenides are later by perhaps two centuries than the temple of Neandria, and if the architects that constructed them suffered to a certain extent the influence of Hellenic art, one can only admit that they were inspired by forms, that had already passed out of fashion in Greece, when they erected the sumptuous palaces of Darius and Xerxes. This analogy remains no less worthy of attention. It is explained by the existence of an earlier type, very ancient and of Asian origin, a primordial type from which equally came by different ways the capital of Neandria and that of Persepolis.

Only in its froper place among the Greeks of Asia, have we so far studied the Ionic art. We now have to follow it beyond the sea into Sicily and Italy, as we have done for Doric art, born in peloponnessus. Some remains exist of one of the most ancient monuments, that it has created in a foreign land; we speak of the temple that the founders of Naucratis hastened to erect in honor of Apollo at the centre of the concession. This temple was entirely of limestone, and is believed to have been built about 620, perhaps earlier.[1] There again we have the order nearly entire; as at Samos it lacks the capital properly so called; only a bit of it exists. On certain columns that perhaps were in the second row, the lower part of the base presents elements analogous to those composing the Samian base, the round and fluted plinth, then the torus with the same horizontal flutes; but here between the torus and the bottom of the shaft is interposed a frustum of a cone terminated by a band above which commence the flutes of the shaft. (Pl. LII,3). The transition thus arranged between two members usually in direct contact is awkward and heavy; it seems that the architect working in a barbaric land has lost something of his refinement and taste, unless we have here a simple roughing intended to receive an ornament, that was n not executed. As at Ephesus, the shaft has yet only Doric f flutes; it ends with a sort of double astragal formed of two rings of leaves (Pl. LII,4); those are summarily indicated and resemble inverted eggs. It is not probable that the column was terminated thus, for there have been found some fragments of volutes cut in the same stone;[2] but these bits are

too small for one to attempt to restore the capital. One can ask whether this capital did not present an entirety analogous to that restored for Neandria (Pl. LII,2).

Note 1.p.628. On the subject of this temple, see Naucratis, Part I, 1884-1885 by W. M. F. Petrie, with Chaps. by Smith, E. Gardner, Barclay, V. Head. Third Memoir of Eg. Expl. Fund. 1886. Pls. III and XIV by Gardner, with an appendix by F. Ll. Griffith. Sixth Memoir of Eg. Expl. Fund. 1888.

Note 2.p.628. Naucratis, Part I, p. 13.

Naucratis is also only an extension of Ionia; but a recent discovery, the uncovering of the ruins of one of the temples of Locres on the eastern coast of Italy, has shown this style of architecture employed in a city not connected by any close bond to the country where it originated.[1] There on the site itself of a more ancient temple, from which remains only the foundations, was built a peripteral Ionic temple about the middle of the 5 th century; important fragments of the order have been found. The base much recalls that of Samos (Pl. LII, ,, 6); but one here sees the true Ionic flutes appear on the shaft, a shallow fluting with a fillet separated by narrow fillets. Flowers ornament the necking; they start in the curved angles forming semicircles in which the flutes end at t their upper ends, and they vary from one column to another. (Fig. 279). One has but a fragment of the capital itself ((Pl. LII, 7, 8).[2] However fractional these remains, one finds there that the little round outlining the spirals of the volutes does not form a continuous curve and is connected to the upper fillet by an obtuse angle, while below was a bent curve joining the two volutes. The cushion forming the lateral part of the capital offers ornamentation less elegant than at Ephesus; for all decoration it has only several superposed rows of scales. That arrangement is of a rather poor simplicity; but in other respects, by the profile of its base, by the section of its flutes, the order of Locres is already very advanced; it approaches the orders whose happy proportions and noble elegance have raised to the dignity if classical models.

Note 1.p.629. Petersen: Temple in Locri, in Arch. Inst. Röm. Mitt. 1890. p. 161-227. Pls. VIII, IX, X. The plan drawn by Dörpfeld was published at larger scale in Ant. Denk. I, Pl.

LI. Also see P. Orsi. Scoperta d'un tempio ionico, etc. (Not. d. Scavi. 1890. p. 248-267).

Note 2.p.629. Fragments of a necking ornamented in the same taste have been found at Naucratis (vignette at end of Chap).

In the course of this survey, we have not met with the ruin of a single edifice, that presents the appearance of the temples of Paestum, or even that of those of Corinth and of Egina; neither in Asian Greece nor outside its frontiers have we found a single Ionic column still standing on its base a and surmounted by its capital. We have only endeavored with greater care to collect and represent all the fragments, which can give an idea of the character of the forms created a and employed by this architecture, in its initial period and up to the middle of the 5 th century. It remains for us to compare and classify the forms, to group them in series, and to follow the progress of the work, which from generation to generation made them more harmonious and more beautiful.

The temple of Neandria is certainly more ancient than the temples of Ephesus and of Samos; there are serious reasons for dating the construction in the 7 th century.[1] If this be so, the type with abutting volutes would represent the primitive form of the Ionic capital, and until being more fully informed, there would be reason to regard Eolia and its appendage Lesbos as the cradle of that art. In that region were made the first attempts, sketches and preludes of the future masterpiece. As the domain of that art extended, occasions multiplied to use it, to retouch and correct the motives that were first sketched, to reform or to inflect the lines of its design to better satisfy the eye. Taking outside Asia in the islands of the Archipelago and in continental Greece, a certain number of archaic capitals, that served as bases of statues, one sees the type gradually modified; he notes variations from one to another, slight changes in design, by t the effect of which the capital with abutting volutes is transformed into a capital with volutes connected by horizontal lines.

Note 1.p.630. Koldewey. Neandria. p. 49.

For example, here is a capital found at Delos (Pl. LIII,1, 2).[2] The volutes are only indicated here by lines traced with the point, lines formerly heightened by color; they present

in general nearly the same arrangement as at Neandria; but they are curtailed as not even joining at their beginning. They lie extended on the plateau, that has a rectangular surface at its upper part to follow their movement rounded at the sides. The top of the shaft is attached to the horizontal plane separating the two cylinders. An ornament painted like a palmatium fills the interval that separates the volutes. When one attempts to restore mentally the capital of the Samian Hera, he would be sufficiently disposed to believe that cylinders of this kind were suspended there at both sides of the echinss, the only part of the whole known to us; this w mill explain why there is no interruption in the row of eggs extending entirely around this abacus.

Note 2.p.630. Sketches of this capital and of another from the same source (Pl. LIII,3) have already been published by Homolle (Les Travaux de l'Ecole francais dans l'isle de Delos. 1890. p. 27-28). Our thanks are due to M. Nenot, who courteously placed at our disposal his original drawings.

To return to the capital of Delos, there is awkwardness o both in the general form of this plateau and in the absence of all relation established between the two volutes; yet this capital already has an entirely different appearance from t that of Neandria, with which it still has certain common traits; it is nearer the forms that classical art has rendered familiar to us. A simple annulet, here traced with a brush, ornaments the top of the shaft.

A capital from the Acropolis of Athens marks a step farther in the same path. (Pl. LIII,4). This is a surface terminated by an abacus cut in the mass and rounded at the sides. The volutes are separated by a light palmatium and present an a arrangement analogous to the Delian capital, but with the d difference that they are varied at their springing by a horizontal bar in which one can see the beginning of the channel, which will later connect the spirals together at top.

Progress is marked in a still more sensible fashion in a second capital from Delos (Pl. LIII,3). The volutes are there independent of each other; the palmatium is again interposed between them; but the starting point of the spirals is at the top of the capital in the horizontal plane, instead of being on the shaft. The direction of the volute is reversed; the

change is notable. They were occupied in forming a happy junction between the shaft and the surface. The shaft is here surmounted by an echinus, which is far from having the amplitude of the Doric echinus, but is decorated by a row of eggs.

A monument whose place is marked in that series of transitional types is the marble column, which at Delphi supported the sphynx erected by the Naxians on the sacred way in honor of Apollo; recent excavations have allowed the fragments to be put together and the entirety to be restored (Pl. LIV).[1] The shaft has 44 flutes there, but these flutes are stoll those of the Doric. On the other hand, on the capital the volutes no longer form two distinct motives. A little smaller at the sides than the shaft, they are connected at their springing by a horizontal band. They no less develop fully entirely outside and at a distance from the shaft; they are sufficiently distant not to interfere with the row of eggs that ornaments the echinus. That assumes an importance on this capital, that it will not retain later; it is higher than the band connecting the volutes.

Note 1.p.632. Pl. LIV. The capital in perspective, from drawings of Tournaire. 2; plan as seen from below. 3; Elevation of capital. 4, side elevation. 5; transverse section. 6; plan of capital seen from above.

The capital of Delphi has the volutes still present, those detached and falling forms, that characterize several of the capitals previously described (Pl. LIII,1,3); but the transformation is completed; a last capital found on the Acropolis of Athens (Pl. LIII,5). There by the effect of the connection established between the volutes, the capital is no longer composed of two elements juxtaposed instead of being combined, as on the first sketches of the type, it has its unity; but on that work of real elegance, the band connecting the two spirals forms at bottom a curve, whose gentle inflection is much more in harmony with the curved lines of the volutes, than was the stiffness of the two parallel s.raight lines, which fulfil the same function on the capital of the Naxians. (Pl. LIV,3). Further, here the volutes at the sides approach the echinus, where the eggs are painted and not carved,sufficiently to encroach on and intersect it, so as to conceal a part from the eyes. To be noted also is the form of the

cushion, which is thinner at the middle; it thus assumes more lightness and a certain grace. The two sections opposite (Figs. 280, 281) show what precautions were taken to prevent all displacement of the votive offering borne by the column, a stele or statue. A long bar of metal formed the connection; it passed entirely through the capital and was cast in lead entirely around it. This was placed in the funnel shaped hole cut in the top, filled the cavity formed at the middle of the block, thus surrounding and fixing the foot of that dowel.

We thank MM. Homolle and Tournaire for the courtesy with which, for both the column of the Naxians as for the treasury of Cnidos, they placed at our disposal drawings executed for the publication in which are to be presented the results of the excavations at Delphi.

The block in which is cut the Ionic capital being always of rectangular area, the capital could be without the abacus. (Pl. LII,1,2; Pl. LIII, 2,3); Where it exists, as on the two last capitals described (Pl. LIII,4,5), it is always cut in the same block as the two volutes. Actually, this is only a simple fillet, merely a moulding serving as an ornament. A fret of very careful execution is traced with the brush and decorates it on the capital of Athens, that we have regarded as the last term of the series of archaic capitals.

With this capital that at latest dates from the first years of the 5 th century, we feel ourselves very near the classical capital. Men have not failed to observe that from Neandria to the column of the Naxians and the votive columns of the Acropolis, the top surface has always been flattened and enlarged. When in the Doric style the stone entablature was substituted for that of wood, the architect must have given his abacus an extension, that it did not have in the Mycenaean capital. It was the same for the constructor that employed the Ionic style. The moment came when he must replace by stone beams the light wooden beams, that the primitive capitals sufficed to support; in changing the arrangement of the volutes, it was then necessary for him to arrange a longer bearing area at the top of his capital. By this change the capital becomes suited to receive a heavier burden and to appear so; the eye demands that the architectural forms inspire it with confidence, to arouse in the mind the feeling of entire

security. It is so far from that work of an already wise art to the strange types, that have seemed to us to be its precursors, there is the labor of many generations of anonymous artists. Grecian genius has done its work, that genius which was never satisfied by the result obtained, and which during the ages did not cease to seek better, always applying itself to resume certain forms with a passion never wearied, to bring them to perfection in letters as in arts, in quite limited number, that it had invented early and whose future it had divined. In the domain of architecture one of the noblest of those forms was the column, and particularly the Ionic c capital. If one possessed the entire legacy of antiquity, h hundreds of capitals differing from each other in some trait, would represent the effort that the architect imposed on himself in the course of the intial period to create and develop this type. Time has spared but very few of these sketches; Yet perhaps we can have an extended list of monuments to which our observations have been devoted. We have refrained f from multiplying their number; those which we have presented have seemed to us sufficient to render very probable the hypothesis of a movement operating in the direction indicated by the order in which we have arranged the few examples, that we have chosen. Those understood, the movement indeed has the characteristics of an organic evolution.

Besides the type that by the junction and inversion of the volutes ended by giving the capitals of the Attic temples of the 5 th century, there seem to have existed another, that passed almost unperceived until recent times. What there composed the capital was an echinus concleaed beneath a facing of elongated and ascending leaves, whose ends meeting the a abacus, recurved and fell downward outside. For example, such is a capital of Delphi, that came from the monastery of the Panagia, i.e., from the ancient gymnasium (Fig. 232).[1] This is the same capital that was found in one of the porticos surrounding the temple of Athena Polias built under the Attalides at Pergamon, as well as in other edifices of the same epoch (Figs. 283, 284, 285).[2] Like the capitals with falling leaves of Neandria and of Aegae (Figs. 277, 278), this capital constructed on a circular plan was especially suited for columns erected at the middle of a void space in which circu-

circulated the promenaders. One is inclined to think that t this type was particularly employed for the internal supports of porticos;[1] my its entire form it assumes a light load. The columns ending in that way perhaps directly supported the b beams of the ridge of the carpentry; in that case they would have been taller than those of the outer rows, and the architect would have desired to distinguish them by giving them a special capital.

Note 1.p.636. Antiquities of Athens and other places in G Greece, Sicily, etc. 1830.

Note 2.p.636. Fragments of a capital thus cut as a calthos, but provided with an abacus, were found at Athens in the portico of Attalus; they seem to have come from an internal order. Other capitals of the same kind have been found on the southern slope of the Acropolis of Athens. They must come f from the Asclepion.

Note 1.p.637. R. Bohn in Altertümer von Pergamon. Vol. II. Note on p. 48.

Properly speaking, this capital indeed depends on neither the Doric nor on the Ionic style. If we mention it here, it is because it presents a sensible relation to those, which according to Dörpfeld surmounted the 7 columns of the nave of the temple at Neandria, an edifice of the Ionic style. (Fig. 277). The curve outlining the contour of the capital is convex at Neandria; it is concave at Delphi and Pergamon; but on both a bouquet of leaves crowns the shaft, and alone ornaments the top. The principle of the decoration is then the same, both at Neandria and Aegae as at Pergamon. Small or large, those three cities were situated in the district formerly peopled by the Eolian tribes. If then one desires to give a special name to the order characterized by that exclusive use of leaves for the decoration of the capital, it seems that it can be called the Eolian order, or when one only considers the form that it assumed in the monuments of the classical age, the calathos order. Perhaps it is necessary to see there the ancestor of the Corinthian order. We shall have to seek later, whether at the origin that was not constituted by the stone calathos on which were applied bronze ornaments in a very peculiar style, but which on the whole had their prototype in both the Ionic volutes and in the Eolian

leaves. These leaves further supply up to the present time the sole trait by which one can define that order. The shafts are plain at Neandria, Aegae and Pergamon. For Neandria and Delphi, the base is wanting. At Aegae and Pergamon the bases are Ionic. In general the capital has no abacus, or that abacus is very much reduced; a wooden beam must have rested on the columns.[1]

Note 1.p.638. The capital of Delphi is surmounted by a heavy abacus in the engraving by Cockerell, that we have reproduced; but the manner in which it is presented gives reason to think that this abacus is a restoration, added there by the draftsman. The explanation of the plate gives no indication on this point.

We should mention this forgotten order; but the masters t that built the most celebrated edifices of Greece did not a admit it in their arrangements, or at least in their external arrangements, those alone of which there remain fragments of some importance; they did not subject it to that slow and w wise elaboration through which passed the Ionic style. In t the effort that it made to comply with the requirements of taste and to adapt itself to the progress of luxury in construction, the latter not only labored on its own basis by applying itself to perfect the forms peculiar to it, but it was also inspired by forms given by Doric architecture. With regard to the general arrangements of the edifice, we have shown how the architect who employed the Ionic style was led to reproduce with other elements the consecrated type of the Doric temple; but even before abdicating thus its primary f freedom, it was inspired by this model for many details, that have their importance. Thus one cannot refuse to recognize a sensible analogy between the angle triglyph of the Doric frieze and the two pairs of volutes presented by the angle column of the Ionic portico (Pl. X,1). Place on that column a capital similar to the others, and the spectator passing around the edifice would have before him at one point of the exterior only the volute, the part of the capital not made to be seen directly in full light, but which is affected by the shadow cast by the architrave and almost escapes from v view; the appearance of that angle would have something awkward and defective. Like the doubling of the triglyph, that

of the joined volutes allows this defect to be avoided; by it the capital has the same appearance on both facades, if one may so speak, which ensures to the angle all desirable firmness. The two arrangements do not apply to the same part of the building, but were suggested by the same need; they solve with equal success two problems with data almost similar. In the Ionic style, the difficulty did not exist in the frieze, which was continuous; but it presented itself for the capital, which deffering from the Doric capital had what may be termed a front and an end. According to all appearance, this arrangement adopted for the Doric frieze gave the idea of the method adopted for the Ionic column.

It was for the ante as for the angle column. Here, as in the Doric order, a capital was given to the ante, which is not that of the column, while recalling it in certain respects by the nature of its decoration. In both, the principle is then the same. What differs is the character of the mouldings. Here are no rude facias, no very marked divisions. The Ionic ante does not terminate with a projecting crowbeak moulding, as the Doric frequently does. What one finds there is a series of very ornate mouldings in low relief, in which are found those presented by the capital of the column,.palmatiums, eggs and ogees (Pl. X,1). This ante is that which one can call the Attic ante. In the Ionic temples of Asia Minor built under the successors of Alexander, we shall find another type. The ante is there crowned by a capital without mouldings, but decorated by two vertical volutes joined at their base by a wide band.

In spite of the tendency which thus marks the assimilation of the two orders, what distinguishes them and will always distinguish them is the appearance and proportion of the columns, without speaking of the originality of the capital. The Ionic shaft is lean; one feels there the imitation of the t trunk of a tree, much more than in the Doric shaft, but of a trunk resting on the ground at its lower end, and which thus resembles the mast of a ship. This wooden support from which it appears to be derived, it is not necessary to insert to change it into a stone support, as required to be done for the Mycenaean column. For the column as for the entablature, timbers of quite small size served the constroctor to whom

succeeded the Ionian architect. The use of these methods gave a long and slender column, whose stability would have been compromised if the drums had been multiplied too much; it is rare for more than three or four to enter into the composition of the Ionic shaft.

The architect appears to have hesitated long as to the style to be given to the shaft. At Neandria, Samos and Aegae, he left it plain. More frequently he ornamented it by flutes. On most monuments of the archaic age, these are entirely similar in section to the Doric flutes; but are narrower and are repeated in greater number around the shaft. It is rare that on the Ionic column the number of flutes is less than 24, and it sometimes rises to 40 as at Ephesus, and even to 44 on the column of the Naxians at Delphi. Finally, the flutes bordered by fillets only appeared quite late, and only from the 5 th century a custom without exception applied it to the Ionic temple. When the Ionic approached the Doric in other respects, it commenced about that time to separate from it by this secondary trait.

On the other hand, the difference of proportions is accented from the origin and has always maintained. The Ionic was born more slender than the Doric, as one ~~might~~ may say, and so remained while it existed. That is to the point that the thickest of the columns is still thinner than the most slender of Doric columns; thus the Ionic shaft has a less marked diminution; it presents nothing comparable to that curve that we term the entasis.

3. Entablature, Carpentry and Roofing.

One would be much embarrassed to form an idea of what the entablature might be in the most ancient Ionic edifices, if it were necessary to require information only from the remains of the buildings; nothing remains from their friezes and cornices, which gives reason to think that the entire upper portion of the structure was of wood; but what was the character of that carpentry work? We should know nothing here, unless in that country itself that was the cradle of this architecture, one did not find rock-cut tombs, whose fronts are decorated by an Ionic order. Doubtless tombs are generally very much later than the monuments in which we have sought the secret of the methods and taste of this growing art;

but we have stated with what scrupulous accuracy the workmen that cut those tombs in the rock, endeavored to reproduce the forms presented around them by the house and the temple.[1] We take our examples from conservative Lycia. The number of tombs there with their roofs in form of a pointed arch, and t their visible trunks that support the weight of the terrace are a literal copy of the house of the Lycian mountaineer. We do not turn to those; their forms are too peculiar and t too rustic. The tombs that appear to us able to furnish the desired information are those in which is still maintained the tradition of the primitive methods of construction and of the assemblage of the carpentry appropriate to them, but where Greek taste has already sensibly modified the indigenous and local type, certain elements of which have entered into the system of forms, in the style of architecture that he labored to create. As a specimen of those facades, we have chosen a tomb of Telmissos, of which we show the angle in p perspective (Pl. X,3). Other tombs of the same kind can furnish us with indications, that accord with those that we owe to this monument.[2]

Note 1.p.641. Histoire de l'Art. Vol. V. Figs. 250, 251, 260, 261, 262, 264, 265, 266, 267.

Note 2.p.341. Texier. Description de l'Asie Mineure. Pl. G-I, 171. We should have had only the embarrassment of choice, had we desired to seek our examples in the series of Phrygian tombs of the elevated valley of Sangarios (Histoire de l'Art. Vol. V. p. 140, Figs. 92, 97). There also is found the architrave cornice with the row of dentils, that extends everywhere beneath the cornice.

The mode of the entablature that may be divined from that assumed architecture sensibly differs from that offered to us by the Doric entablature. Like it, it is doubtless derived from wooden construction; by that are explained the forms that characterize it in stone construction; but it assumes in the edifices of the primary age that served as models, t types of carpentry very clearly distinguished from those that we have restored at Mycenae. It suffices to glance at one of those facades to recognize that it was with the parts of the entablature as with the supports of the portico; in the entablatures of wood of which we have a stone translation, the

beams composing the architraves were of much less size, than those playing the same part in the carpentry, whose arrangement was reproduced by the Doric entablature. The Mycenaean carpentry was composed of solid and large beams, each of which had its special function, and constituted in itself alone one of the architectural membees. This Asian carpentry on the contrary, was only composed of timbers of moderate size, that could play all parts indifferently. The adjacent theoretical sketches will illustrate the arrangements to which the use of these timbers led, arrangements produced by the mode of construction termed piling (Fig. 236).

Several courses of beams there form the architrave. There are certainly two indepth and two or three in height. In elevation each of these beams, whatever their number, projects slightly from that supporting it (Fig. 236).

On these architraves, thus composed of 4 to 6 timbers, with no other intermediary than the wide plank that serves to cover the joint, rests a floor made of nearly similar beams (Fig. 237). As in the Mycenaean megaron, there is necessarily a r row of beams perpendicular to the main axis of the building; but what is peculiar to the Ionian ceiling is, that there are also beams placed in the longitudinal direction (Fig. 238). Thus is constituted an open lattice that presents in all directions a sort of square openings. The ends of the beams everywhere project beyond the architrave on which they rest, so as to be visible on the four sides of the edifice. This arrangement can be secured only by a special arrangement, that seems to have been employed particularly in Asia Minor, and that is termed halving (Fig. 239).

Covered by thick planks, beams placed lingthwise would largely suffice to bear the load of the terrace. Everything considered, one can affirm that also the solidity of the ceiling would be well ensured, except by this crossing of the two series of beams. The gains required by this procedure in connecting weakened these beams. There is then a method pursued, which is explained only by the search for an ornamental effect; men found pleasure in seeing project thus on the four facades above the plain walls or the openings of the portico, these uniform and symmetrically arranged ends of beams; it is probable that most frequently the end was painted a vivid

and perceptible tone, that gave that series of reliefs the character of an ornamental motive.

In that restoration of the primitive carpentry of the Ionic building is nothing,conjectural. By considering the most ancient Ionic capitals, such as those of Neandria and of Lesbos, one already divines how small were the beams that they supported. There was not space for a beam of great size on the very small area left between the volutes. But this indication would not have sufficed. What has permitted us to restore the entire system of Ionic carpentry is an attentive study of the monument of Telmissos (Pl. X,3); one there finds sensibly enlarged all the elements represented in our sketch. The architrave is there divided into two lintels, which morrespond to the two superposed beams of our drawing; the lower band recedes slightly behind the upper band; over that a narrow fillet represents the covering plank. The contrast is marked between the division of the Ionic architrave and the unity, that the Doric architrave always retains.

Over the architrave here projects a rectangular ornament known by the name of modillion. It naturally represents the ends of joists, and its presence on two adjacent facades is explained only by this system of crossing of the beams evidenced by all Lycian tombs by the projection of the ends of the joists on the four faces. This same ornament is called dentil, when of smaller size; the dentil differs from the modillion only in dimensions; it assumes a ceiling of the same arrangement, but made of smaller timbers.

On the tomb of Telmissos, these modillions are surmounted by a slightly projecting cornice. That corresponds to the facing, to the border that served to retain in place the tamped earth of the terrace.

In the primitive Ionic entablature, such as it may be seen behind these copies of dates more or less recent, there is then no place for the frieze. At Telmissos the entablature is what architects term an architrave entablature, i.e., where the cornice rests directly on the architrave. It is no longer thus on the Ionic monuments of the classical age. The entablature has suffered the influence of the Doric style. Men did not take from the Doric the solemn rhythm of its triglyphs, which would not have been in accord with the more i

irregular arrangement of the richer and freer elegance of the Ionic edifice; they contented themselves with a continuous lintel, which the sculptor could be called to decorate by f figures or by varied ornaments, and which even when it remained plain, had the advantage of giving to the entablature more height and a happier proportion, analogous to that of the Doric order. This method was most generally adopted; yet they sometimes departed from this rule. Whice there is not and cannot be an example of a Doric monument with an architrave entablature, that is found at Athens itself on that porch of the Cariatids, which formssa part of the Erechtheum.[1] It is again found on the Leonidaion of Olympia and on the p portico of the great altar of Pergamon. Although few, these exceptions evoke the memory of the original type; they suffice to attest, that the frieze in the Ionic style is not indispensable to the entablature; they show in what conditions and under what influences the architect judged it well to insert it.

Note 1.p.645. As perhaps a unique example of an architrave entablature in a Doric edifice, one can cite that crowning the substructure of the second portico in the Abaton of Epidauros. (Cavvadias, Fouilles d'Epidaure. Vol. I, Pl. XII, Fig. 31). This second portico further is later than the Roman conquest, at least in part.

Of the traits that characterize the prototype to which we have believed it possible to ascend, that which is most faithfully preserved on the later monuments, is the division of the architrave. This is divided toto three facias on the entablature of the temple of Wingless Victory (Pl. X,1), that of the Erechtheum (Pl. X,5), and on that of the temple of Athena Polias at Priene (Pl. X, 4). On the contrary, the modillions and dentils were not to the taste od the architects, that introduced the Ionic style at Athens, and their example was followed by the masters that practised the same art in the other par.s of continental Greece; there are modillions neither on the temple of Illisos, at the Erechtheum (Pl. X,5), nor on the temple of Victory.(Pl. X,4). Only in Asia Minor has been retained the habit of employing that motive; all around the temple of Priene, a row of modillions seems to support the cornice (Pl. X,4). One can then distinguish in the

Ionic of the classical age two different modes; the Attic a and the Asian modes.

In the most ancient edifices, the ceilings of the portico and of the cella can only be of wood. The form of the coffer was imposed to fill the spaces left between the timbers, and the procedure by which the carpenter obtained it could not bedifferent from that described in regard to the ceilings of the Doric temple. As for those, the coffers of ancient wooden constructions in the Ionic style are represented only by translations of them given by stone in the edifices of quite recent date; under that title we have represented the coffers of the temple of Wingless Victory (Pl. X,2), and that we show those of the Erechtheum of a different appearance (Fig. 290). All the difference is, that in the Ionic building, the coffers seem to have corresponded with more rigorous symmetry to the axes of the columns and to the intercolumniations. As a type of this entirely geometrical regularity, it will suffice to cite the elegant edifice known under the name of tomb of the Nereids, which was brought from Lycia and entirely reconstructed in one of the halls of the British Museum. Further, the coffers in the two styles are not in accord with the same parts of the building. In the Doric, they rest on the courses of the frieze; consequently they are at the level of the cornice (Pl. VIII, 3-6); on the con.rary in the temple of Victory, they rest on the architrave (Pl. X,2).

On the great temples, such as those of Ephesus and of Samos, the principle of the carpentry of the roof must be the same, as on the Doric temples where the cella had an internal order; but neither the entablature nor the wall of the pediment being preserved on either of these edifices, there remains no trace of the arrangements adopted in this matter by the Ionian architects. Of the monuments of this period, there is o only one that from this point of view supplies some useful indications to the historian; this is just the most ancient of all, the temple of Neandria. Being given the position of the columns that divide it into two aisles, the carpentry must present there a very simple arrangement;[1] the tiles have been found, and these present varied forms, according to whichis restored a covering, which does not essentially differ from that, whose arrangement we have studied on the edifices

of another style and of a later age; it is that illustrated by the perspective view of a part of that roof (Pl. X,6). One distinguishes there flat tiles of very large dimensions, (they are 1.74 + 2./6 ft) and covering tiles; the latter are of semicircular form with a diameter of about 6.3 ins. At the base of the roof, the flat tiles had a raised edge in which opened a projection that cast the water outside; the covering tiles ended with a semicircle forming an antefixa, on which was modeled in low relief the front part of a crouching panther painted black. Some fragments of an acroteria were gathered, that ended the row of ridge tiles. According to the slight remains found, it is supposed that it was much smaller and must offer some resemblance in form and ornamentation to the enormous acroteria of the Heraion of Olympia. (Pl. XLVI).[1]

Note 1.p.646. Koldewey. Neandria, p. 43, Fig. 85.

Note 1.p.647. The same. p. 46-48.

So that it seems demonstrated, that from the 7 th century the Ionian architect placed a gable roof on the temples that he endeavored to build. According to all appearance, the slopes of this roof here showed a very slight inclination.[2] If the pediment were already outlined at the two ends, it could only be very low; in time it gained in height and importance; but no more for the Ionic than for the Doric style does there exist a monument, which dates back to an age when the temple was covered by a simple terrace of tamped earth.

Note 2.p.647. For the arrangement of the carpentry and the slight slope of the roof, Koldewey believes that some useful indications are found in the imitative architecture of the rock-cut tombs of the elevated valley of the Sangarios, monuments that must be nearly contemporaneous with the temple of Neandria (p. 44); the Phryginans, subjects of Gorgios and of Midas, further maintained intimate relations with the Greeks of Ionia and of Eolia. He especially recalls in this respect one of the most important, but most ruined of these sepulchres, that where the ridge beam is clearly represented at the junction of the two slopes of the roof. (Histoire de l'Art. vol. V. Fig. 71). There are indeed some analogies that merit some attention.

5. The Mouldings.

4. The Mouldings.

There remains almost nothing of the Ionic edifices of the first age; then one cannot undertake to define the elements of the mouldings that characterized this style at its beginning; scarcely can some brief indications be presented for this subject. In the bases we have found the scotia and torus (Pl. X, 7), the ogee on the the column of Ephesus above the relief that decorates the top of the shaft (Pl. X, B). The Ionian architect does not seem to have ever used the crowbeak moulding, that on Doric edifices terminates by such a firm profile the capital of the ante and the projection of the c cornice; he replaced it at the top of the ante by an uninterrupted series of mouldings in which the ogee and quarter round dominate. Mouldings are few on the Attic entablatures. The quarter round or ogee surmount the architrave, and generally one of these two forms terminates the cornice. Above are cymas of different forms; very few ancient examples are known. The egg serves as ornament for very ancient capitals (Pl. X,C; Pl. LIII,3). The dentils and modillions give a very peculiar appearance to the cornice in Asia Minor. (Pl. X,3,4).

What one sees, is that from a very early time Ionic art h had a taste for less sober ornamentation, more florid in detail, less free and powerful than that of the Doric order. This taste will produce its masterpiece at Athens in the decoration of the Erechtheum, as already announced, and appears in the monuments dating from the preceding century. Indications abound. On the oldest capitals the palmatium separates the two volutes rising vertically (Pl. LIII 1,2; LIV, 1,3,4); the flstes ornament the ends of the volutes (Pl. X, D, E; LIII ,3; LIV, 1,2,4); at Neandria the double crown of leaves forms the connection of the shaft and capital (Pl. LIII2), or composes by itself the capital (Fig. 277); on the capitals of the steles, it is the echinus ornamented by eggs (Pl. LIII,3) or by leaves (Pl. LIII,5); the fret painted on the abacus (Pl. LIII,5); the entire Eolian capital with its fully expanded bell of foliage (Figs. 282, 283).

From the last years of the 6 th century, this taste manifested itself with magnificence at Delphi in the erection of the chapel of the treasury, that the Cnidians consecrated t there to Apollo Pythios. The Cnidians spoke a Dorian dialect;

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but they were too near Miletus not to suffer the influence of the arts of Ionia. It was an edifice of the Ionic style, on the sacred way at the foot of Parnassus, that represented the Dorian island of Cnidos. The skilful architect attached to the mission of Delphi, M. Tournaire, measured and drew in place all the arrangements of the edifice; he is preparing a restoration of it.

Note 1.p.648. Homolle has given in Bull. Corr. Hell. (1886, p. 581-602) a very precise description of the treasury of C Cnidos; it only lacks illustrations.

Until the day when these precious documents are delivered to the curiosity of archaeologists, all that one can see in the fragments exhibited in the museum of Delphi is the general character of the edifice. Built of marble from the islands, it presents the plan of a temple with antes and two columns between them, like the treasuries of Olympia. Their height with base and capital is about 15.7 ft. The flutes n have sharp edges there, but are only 18 in number. Only the lower part of the base has been found, and it seems to have resembled that of Ephesus; the capital is wanting. What forms the interest and originality of the little building is that the forms of the different members there are already very e elegant, and that the decoration there is singularly rich. The architect has placed sculpture on all surfaces suited to receive it, on the pediment and the frieze; the latter presents a continuous series of reliefs in which are represented many scenes borrowed from the myths, that poetry has made p popular in the entire Grecian world. where there was not room for figures, there were everywhere ornamental motives of happy design, of precise and even fine execution, where the brush of the painter completed the work of the chisel by the application of vivid colors. Above the frieze extends a bead with very large pearls, surmounted by a Lesbian cyma; above extends the cornice, where on the soffit of the cornice the sma pearl bead serves for a band in which palmatiums of pretty design alternate with open lotus flowers (Figs. 291, 292). The same recurring motive runs along the three edges of the enclosure of the door giving admission to the cella (Fig. 293); but there is more caprice in the arrangement of the foliage; from the stems bearing the opened flowers are detached

buds bending in the inverse direction. The variant is happy; it gives to the garland a less conventional appearance.

When the treasury of the Cnidians was built about the year 520, the motive derived from the inflorescence of the Egyptian lotus had long been in the repertory of the Grecian decorator; he very frequently employed this foliage in which he caused to alternate, sometimes the buds and floners of the lotus, sometimes the latter and palmatiums. The most ancient monuments on which appeared the motive in question is a series of painted vases attributed to the potters of Ionia; it was further soon borrowed from them by the potters of Athens, and thus had come into the public domain.[1] The Attic decorator used it in the painted ornamentation of his Doric cymas after the time of the Pisistratides (Pl. XLVI); if one does not find it on the temples of the Acropolis in the 5 th century, it is seen to reappear on other Ionic edifices. In any case, it seems to have been in the 6 th century the object of a strong preference by the Ionian architect; he repeats it at Delphi on both parts of his edifice. One cannot be astonished: it must be by the entermediary of Ionian artisans, who were first in relations with Egypt, that this motive was disseminated in the workshops of the Grecian world. Men were more attached to it in Ionia than elsewhere; Ionia had become its second country.

Note 1.p.650. This motive is in frequent use on the so called hydrias of Cere, that are believed to be of Ionian fabrication. Massner. (Die Sammlung antiken Vasen in Oesterreichischen Museum. Pl. II, No. 218. Pottier. Bull. Corr. Hell. 1892. p. 257. Fig. 7).For the little isolated bud springing from the same stem, there are examples on Ionian vases still unpublished, as well as on a cup with foot in hall E at the Louvre; but it is more common to see the isolated bud leaving the ground. See Dümmler. Röm. Mitt. 1888. p. 165. Pl. VI, (a vase from Kyma), as well as the sarcophaguses of Clazomene.

The treasury of the Cnidians would have merited a more thorough study, one that would have been the natural and logical end of the researches, that we have undertaken on the first period of the development of Ionic art; one would have seen in what spirit and with what success the Ionian architects had cultivated their national art, and how far they had

had carried its evolution, before the time when the Attic masters will adopt that art and produce the works, which one is accustomed to regard as its masterpieces. However, what results from these indications, insufficient as then are, is than on an edifice like the treasury of the Cnidians, t the Ionic style already presents the most characteristic traits that distinguish it in the temples of the Acropolis of Athens. The same tendencies appear; one there feels the same effort made by the artist to demand from the grace and the profusion of ornamental effects od a kind different from those aimed at by Doric architecture; this artist aspires henceforth to realize a different type of beauty, where the whole has less grandeur, but which must please especially by the singularity of finish of the details. The architect to whom the Cnidians confided the direction of this work did not have at command collaborators with such delicate hands as the incomparable workmen, who carved the capitals and friezes of the temple of Wingless Victory and of the Erechtheum; but he had the same tastes and the same feelings; he conceived the same ideal. We thus come here to the same conclusion as by the study of the monuments of the Doric order; t the 6 th century was the true age of bold and fertile invention. This is what makes the edifices of the 6 th century so interesting; it is what justifies the attention that we have accorded to them and the place that we have assigned them in this history. Later and especially after the 4 th century, art will repeat itself; more than one temple will be, with variations in details, only a replica of a model already consecrated by universal admiration, only an enlargement or a reduction of its model, a copy more or less free. In the 6 th century Grecian architecture is made; each new work, when it does not represent an advance accomplished, at least earns the name of a personal effort, of an intelligent and sincere endeavor. That century has created all the original types. The 5 th century has added almost nothing to this treasure of forms, no more in architecture than in sculpture; its merit and its honor are only to have attained that mastery and that certaintyin execution, that impresses on the work of a art a character of perfection, by which it can never grow old, and must hereafter be forever proposed for study and

imitation.

It is scarcely necessary to indicate, that also the Ionian architect used color to distinguish from each other the different members of the building, and to enhance the effect of his ornamental motives; very apparent traces of polychrome decoration are preserved on the temple of Locres, the treasury of the Cnidians and on the capitals of the steles of Delos and of Athens (Pl. LIII,1,5). Its principle was the same as that of the Doric style; but did this decoration present a peculiar character on the edifices erected on the soil of Ionia? Did the architect there make use more largely of tones applied on stone, and what were those tones applied by preference? The remains of Ionic temples preceding the 5 th century are in too small number, and have reached us in too fragmentary condition for it to be possible to reply to these questions. All that one discovers is, that the painter must have been called there to lend to the sculptor a more active and more continuous assistance, than on the edifices of the Doric style. The ornamentation of the Ionic was more complex and more delicate; to accent the refinements that he sought, to give to his entireties a very rich and brilliant appearance, the architect had still more need of the collaboration of the brush. Facts confirm these conjectures. The painted ornamentation is already of very refined elegance on the steles of the Acropolis, and for the Erechtheum it is known to what selected artisans the execution was entrusted; this is evidenced by the designs, whose vestiges are still perceived on the marble, and the texts that have transmitted to us the accounts of the work.

Chapter V. Comparative Study of the two Orders. Their Origins.

In this history of Grecian architecture we have assigned the first place to the Doric temple. We have considered it in all its aspects; we have followed it in all its ascending movement from the foundations on which it rests to the apex of the pediment, to the long line of ridge tiles. We have endeavored to recover much rather from the monuments themselves, which are numerous, than in the texts, which are rare and often obscure or contradictory, the entire system of rules that in time were evolved in the practice of the ancient constructors. The Ionic style came only in the second place, and the study of the methods peculiar to it has been far from having the same development. Yet in antiquity this style did not enjoy less favor than its rival; it even ended by dethroning it. Two edifices of the Ionic style, the mausoleum of Halicarnassus and the temple of Artemis at Ephesus were ranked among what were termed the seven wonders of the world.

The order that we have followed and the difference that we have made are not explained merely by the chance of destruction, which for the archaic period spared more Doric than I Ionic temples; there are more serious and more profound reasons for this precedence and greater importance assigned to the Doric style.

Like all creations of literary or formative genius, Doric art had its antecedents from necessity. It was not born in a day by a sort of miracle. By its roots it descends into the past; but this is not the past even of the people to which is due its blossoming and expansion. One knows what an idea we have formed of the tribes, whose work is represented by the monuments of the civilization called Mycenaean; we believe that they have furnished certain elements, which entered into the composition of the Hellenic race, perhaps those that have played in the formation of this ethnic type the most useful and the most decisive part. The constructors of the walls, palaces and temples of Mycenae and of Tiryns must be counted among the direct ancestors of the historical Greeks. The imagination of those protohellenes traced the first sketch of the epic poem, and the palace of their princes, t the megaron, was the pattern by which was cut out the form of

of the Doric temple.[1] If that is larger and more beautiful than the megaron, this superiority of the temple is explained by the progress of religious beliefs, and by the substitution of stone for wood; but under all the additions that it has received, behind those rows of columns that have come to enclose it, the primitive type always allows itself to be recognized; it persists until the latest hour. As heir and continuator of Mycenaean art, Doric art is then especially the national art in the domain of architecture.

Note 1.p.654. This was also well seen by Noack (Studien z zur griechischen Architektur, in Jahrb. Arch. Inst. 1896. p. 211-247). We received this Memoir when our theory of the Doric temple was already edited and printed; but we have read it with lively interest. On many points there is a singular agreement between the ideas stated by M. Noack and those at the same time suggested to us by the study of the monuments.

It has merited this title in another way. The cradle of t Doric art is a country situated equidistant from the remote Grecian cities, those of Asia and those of Italy or Sicily. Doubtless the tribes established in that peninsula did not fail to enter into relations with foreigners; but there was no immediate contact. The suggestions received in that way aid them to equip themselves with tools and favor the progress of their industry; they did not weigh so heavily on their minds as to injure their spontaneity. There was every chance that the art developed in these surroundings should be the freest and most sincere expression of Grecian genius; thus one is also to ask himself if the arts of the Orient by the models that they offered, have influenced in even small measure the choice and character of the forms, whose combination constituted the Doric style. If one has sometimes been able to find some traces of that influence, those traces are very slight. In Egypt, in the sole earlier civilization whose temple is known to us by examples in fine preservation, men at first sought the types by which the Greeks were inspired; n now by the entire spirit of its general arrangement, the Egyptian temple profoundly differs from the Grecian temple; this is at least the case for the most imposing edifices that represent it, for those at Sais, memphis and Thebes, that m must have soon attracted the attention of foreign visitors.[1]

It is true that in that country have been found some examples of the arrangement, that among others characterizes the Greek temple of peripteral plan; but as we have stated, those examples are very limited in number. Further, they have been furnished only by edifices of small dimensions. Finally, so far they have not been found on the banks of the Nile except in upper Egypt and in Nubia. For all these reasons, they must have passed almost unperceived in antiquity.[2] They are also distinguished from the Greek temple by one trait with some importance. There are square piers and not columns, that surround the cella, and those piers rest on a stereobate, that forms a wall to the height of the sill entirely around the portico. Quite different is the portico of the Grecian temple. There are never piers but always columns, and these have their feet resting on the floor of the portico itself. The appearance is very different.

Note 1.p.855. Histoire de l'Art. Vol. I, p. 440-450.

Note 2.p.855. The same. Vol. I, p. 401-406, Figs. 222, 229-231.

One can say as much of the character of the principal forms, those that really form the originality of the appearance of the building. Better informed than Champollion, we no longer pretend to recognize in the pretended protodoric of the tombs of Beni-Hassan the prototype of the Doric column and capital.[3] The influence of Egyptian art, so far as there is reason to take it into account in reference to the Doric style, betrays itself only in accessory forms. Thus there are eggs and pearl beads. The eggs of the temples of Athens with their elegant curves, strong relief and the enclosure in which they are p placed, doubtless seem to belong properly to Hellenic art; yet one can perhaps find a sort of sketch in the decoration of the Egyptian monuments, great edifices or small articles of luxury.[1] There the egg is drawn flat and its form is more elongated than in Greece; but it is no less possible that t the first idea of that ornament had been suggested to the G Greek workman by the regular succession of these ovals, such as he saw displayed on the furniture, ivories and jewels, t that Phoenician commerce brought to him. One can also see a sort of sketch of pearl beads in those rows of disks found either on the cornices of buildings or in the decoration of

Egyptian jewels;[2] finally, on the ceilings of Theban tombs, there is more than one example of the use of the fret.[3]

Note 3.p.655. Histoire de l'Art. Vol. I, p. 550-552. The thesis of the borrowings made by Doric architecture from Egyptian architecture has been recently resumed and improved by A. Marquand (Am. Jour. of Archaeol. Vol. VI, Nos. 1, 2); his arguments have not convinced us. One further sees by the title itself of the Article (Reminiscences of Egypt in Doric architecture), that the author presents his ideas only with a prudent reserve.

Note 1.p.656 Histoire de l'Art. Vol. I, Figs. 390, 566, 5 567, 568.

Note 2.p.656. The same. Vol. I. Figs. 391, 569.

Note 3.p.656. The same. Vol. I. Fig. 541.

If the fact of transmission were demonstrated, which is far from being the case, it would still remain that the eggs, pearls and frets are simple ornamental motives, that play in the edifice only a very secondary part, and that further become only very late a current usage in the Doric style. What takes from the comparisons much of their interest is, that we now know the relation that connects Doric architecture w with Mycenaean architecture, and the high antiquity of its first creations. Before the greeks spread in Egypt, the type of the Doric temple was already fixed, at least in its principal lines. We are of those who are willing to date back to at least the 8 th century the Heraion of Olympia, such as p permitted by the recent excavations to be represented with its long and narrow cella, its external and internal colonnades, with an entablature whose divisions must already be t those found on the later edifices.[4] The opening of Egypt would then have had only very indirect and very general effects on the course of progress of Grecian architecture. The sight of those enormous edifices built of limestone, sandstone and granite, must have struck the minds of the Greeks, aroused their emulation and thus hastened the transition from wood to stone among them.[5]

Note 4.p.656. As Noack remarks (Studien, p. 225), the intercolumniations at the angles in the portico of the Heraion are narrower than those of the rest of the colonnade, a reduction that assumes a frieze with triglyphs. It is permissi-

permissible to deduce from that observation that the entablature of the Heraion, even when it was of wood, already presented arrangements that later will characterize the Doric e entablature.

Note 5.p.656. C. Chipiez. Histoire critique des ordres Grecs. p. 237.

From the moment when this substitution had been made, and the Doric style had constituted itself, it was with the forms and proportions characterizing it that were constructed in Greece proper, and everywhere except in Ionia and in the Ionian islands, the temples in which were adored the gods dearest to the piety of the entire people, and notably among the temples were those around which gathered during the great quinquennial festivals the Greeks coming from all Hellenic cities, at the sanctuaries of Olympia and of Delphi.

To this privileged situation, Ionic architecture could not pretend. Between it and Mycenaean architecture was no visible or concealed connection; nothing resembling a more or less direct transmission of methods and forms. Ionic art had as its cradle no longer the peninsula that extends between the Adriatic and Egean seas, but the western coast of Asia Minor, one of those countries that served as frontiers of the Grecian world, and where Greeks and barbarians touched and mingled to the point of mutually mixing. One knows what traces of the Carian element were left in the cults of Ephesus, and how under the reign of Croesus, Lydia made an effort to initiate itself in the ideas, arts and language of that Ionia, that Sadyattes and Alyattes had thought to conquer; yet a a few years and Sardes became a Greek city, the advanced post of Hellenism in the interior of the land. The art that had been born and had grown in those surroundings, must have suffered in a certain degree the influence of the exotic types, which struck the eyes of the Grecian immigrants, when they came to establish themselves on the soil of Asia. By a natural effect of the same causes, the temples built in those distant regions, however great and beautiful they were, had no chance of becoming at least at once, religious centres around which would assemble all the children of the race scattered over such vast areas. This art that seemed thus predestined, if not to remain always, at least during a longer

or shorter time, rather the particular art of a part of the nation, than that of the entire people.

What created the Ionic style is the intimate collaboration of the principal Greek tribes, the Eolians and the Ionians, or to speak more accurately, of the fractions of those tribes that the eddies of the invasions had cast on the shores of Asia Minor. There was no frontier between these two groups to separate them. Between both were very close relations; b both had contributed to found and people Smyrna on that beautiful gulf, whose shores they divided, and where was employed the elaboration of epic poetry. In that the ground of the myths seems to be of Eolian origin; but the Ionian forms dominate in the dialect used by the epic poets. It is nearly t the same for the architecture. The most archaic specimens of this style we have found in the Eolian cities, such as Neandria and Lesbos; but the entirely Ionian cities of Ephesus and Samos constructed the first temples, where this art showed itself the worthy emulator of Doric art by the dimensions of the edifice and the richness of its decoration. The ancients then gave it the name that best suited it; we can have no scruple in employing as they did the terms, Ionic style and Ionic order.

Note 1.p.658. Vitruvius says Doric species and Ionic species. The word order employed in the sense in which we use it, was introduced by the architects of the Renaissance.

From the day that they set foot in Asia Minor, the Ionians were in commercial relations with the peoples, who by the intermediary of the Cappadocians were in communication with t the great states of the valley of the Euphrates, civilized in very ancient times. Later in the 7 th century they become bold sailors; they meet the Phenicians in more than one market, and soon after the first of all the Greeks, they were introduced into Egypt and had chosen a domicile there.

In these conditions, foreign influences must have made themselves felt sooner and more strongly in the Greeks of Asia than in those of the European continent. When a taste for a art arose among the Eolians and Ionians, how can they resist the temptation of appropriating the forms presented to their eyes in the course of their voyages, in the edifices of the rock-cut tombs, as well as those that decorated the very

divesse products of those distant workshops, from which were transmitted the procedures of the many secular industries of Babylon and Nineven, Sidon and Tyre, Mempnis and Sais? There were those forms, if one can so speak, then current in the world, in all western Asia and in the valley of the Nile. t The volute was one of those most widely disseminated, that filled the most varied purposes. The question has been asked if the first idea of the volute was suggested to the ornamentist by the scrolls of metal wire, by the tendrils of the c climbing plant, the reversed sepals of floral calyxes, or by the horns of the goat and the ibex.[1] It matters little; what is certain is that one finds the volute, already elevated to the dignity of an ornamental motive, on many monuments of o oriental art, that are earlier than the time when the Asian Greeks commenced to build their temples. When their architects had in view their work, the volute appeared to them in the rich repertory of exotic forms under two different aspects; there were two types, that can be followed by traces during the duration of the entire period of elaboration: each of them, so to speak, has its direct posterity among the varieties of the Ionic Grecian capital.

Note 1.p.659. Histoire de l'Art. Vol. II, p. 218-222.

First type, the stilted volute. The two volutes opposite each other at the top of the shaft are joined by an arc, a stilted curve. Thus are they presented on the columns of the little structure represented on the rocks of Boghaz-keui in Cappadocia.[2] That arrangement is reproduced in more elegant drawing, but almost line for line on the capital that decorates the column of the internal order of the temple of Bassae.

Note 2.p.659. Histoire de l'Art. Vol. IV. Figs. 314, 321.

Note 3.p.659. Puchstein. Das Ionische Capitell.Fig. 216. A marble capital found in the Heraion of Olympia presents t the same arrangement. (The same, Fig. 22).

Second type, independent of each other the volutes abut a against each other in pairs, after the fashion of crosiers, whose terminal spiral is turned outside. This is the arrangement that we have mentioned at Neandria and on other archaic capitals (Pl. LII,1,2; LIII,1,4). It is unnecessary to search long to find the model. One finds it in Egypt in the paintings of ceilings and in the columns painted on the walls

of tombs,[4] in Assyria and Phenicia on reliefs on which are represented edifices,[6] on furniture and ivories,[5] at Cyprus on funerary steles.

Note 4.p.659. Histoire de l'Art. Vol. I, Fig. 541-546.

Note 5.p.659. The same.II. Figs. 71, 75, 78, 80; III,612.

Note 6.p.659. The same. III. Figs. 51, 52, 152.

Especially by this last type, men seem to have been inspired at the beginning in Eolia and Ionia; but although rarer, the other type was unable to escape the curiosity always aroused. Did a capital of the sort of that of Boghaz-keui suggest an idea of combining the volutes previously abutting by connecting them either by a right line or a bent curve? Or indeed is it only necessary to see in this progress the effect of the incessant labor of the Greek mind, a sort of organic evolution?[1] It is difficult to decide this matter; but there being given the predilection that the oriental ornamentist had for this form of volute, one can scarcely doubt that its examples were for much in the method taken by the architect among the Greeks of Asia, when he made this motive the essential member, like the ensign of the capital of the column.

Note 1.p.660. One finds the junction made by a straight l line on an Assyrian capital. (Histoire de l'Art. II, Fig. 77).

Primitive Ionic capitals, those of Neandria (Pl. LII,2) a and of Naucratis (Pl. LII,4), have presented to us another element than the volute, the double collar of falling leaves. Whether this collar alone formed a capital or indeed was placed beneath a pair of volutes, this motive is always found employed in the same manner as the terminal decoration of a cylindrical shaft, on more than one monument of Asian art a and notably at the tops of the verticals of a bronze throne, entirely Assyrian in style, that was found in Armenia.[2] From the example of this furniture, one divines how could reach even the Ionians such works of oriental artisans, that were suited for transport to a long distance, and on which the a architect found useful suggestions.

Note 2.p.660. Histoire de l'Art. Vol. II. Fig. 383. See F Fig. 386.

It is not alone by this trait that the Ionic column recalls the memory of what one may call the Asian column. That almost always has its base, whether it be an independent support or a simple pillar. In Assyria a great torus of very heavy app-

appearance alone forms the base.[3] In Persia the torus is placed above either a square plinth or a bell ornamented by reversed leaves;[4] but everywhere appears the torus, the princIpal element of the Ionic base. In it is a scotia balow the torss; now also this moulding is always sketched in the Assyrian base.[5] We find again this torus alone forming the entire base on the pilasters that decorate the angles of the interior of one of the most beautiful ancient tombs of Phrygia of the Sangorios, that which we have called the broken tomb; a simple fillet there separates it from the shaft.[6]

Note 3.p.660. Histoire de l'Art. Vol. II, Figs. 82,86,87,88.

Note 4.p.660. The same. Vol. V. Figs., 309,310,311.

Note 5.p.660. The same. Vol. II, Fig. 85.

Note 6,p.660. The same. Vol. V. Fig. 98.

It is true that the palaces of Persia are very much later than the most ancient Ionic monuments; but it is no less certain that this stone architecture continues the traditions and in general reproduces the forms of an earlier architecture peculiar to Iran, in which wood played the principal part. If this be so, is it by the imitation of a model borrowed f from Greece, that it is proper to explain the analogy mentioned between the profile of the Ionic base and that of at l least a part of the Persian base? Is there not rather a reason to go back to a more ancient type, which for centuries had been in current use in all western Asia? From that common ancestor came in different ways the closely related forms, that are found in both Persia and in Ionia.

Note 1.p.661. Histoire de l'Art. Vol. V. p. 496-505.

Another relation between the Asian column and the Ionic c column is the narrowness and the large number of its flutes. If there be 40 at Ephesus, one counts at Persepolis from 32 even to 52. For the section of these channels, there are two different methods in Asia and in Greece. At Persepolis the flutes are tangent, as on the Ionic monuments of the 6 th century; but in Assyria an altar and a stele already present the model of that fluting bordered by a fillet, which ends by becoming a characteristic trait of the Ionic style.[2]

Note 2.p.661. Histoire de l'Art. Vol. II, Figs. 107,110.

Beside the capital that shows the use of the volute, we have placed another, that we have called the Eolian capital,

Asia Minor, as around the temples of Syria and of Cyprus, with lodgings for the servants of the god or goddess, with wide porticos where the merchants stood, the curious circulated and the believers were stationed; at least this is attested for the temple of Ephesus by the condition of the ruins.

If the Ionian architect appears to to have commenced by employing elements supplied to him by the arts of Asia and by his methods of constrmction, he at once applied himself to a appropriate these elements and place his stamp on them, to fuse them into an entirety which should satisfy a peoplel w whose imagination had already created the elevated and noble figures of the immortal gods. His principal effort was devoted to the column. He occupied himself in fixing its proportions, profiling tae base, regulating the number and section of the flutes, and in perfecting the capital, at first injured by a certain incoherence. We have seen what pains he took to succeed by successive improvements in giving to the volutes the happiest arrangement suited to this motive.[1]

Note 1.p.662. This question of the origins of the Ionic architecture has strongly aroused the curiosity of archaeologists in recent times. We shall not refer to the works of learned men, who were ignorant of oriental art, although one can find curious observations in the Memoirs of Hogg, On the origin of floral Ornaments, the Ionic Volute, and the wave line of the ancient Greeks. (Trans. Ry. Soc. Literature. II Series. Vol. II, 1847, p. 179). Among more recent studies, and that are based on more extended information, we shall content ourselves with citing the following works, which have appeared to us especially interesting, either by the views there expressed, or by the choice of the illustrations in them.

Ussing. Die Graske Soile etc. 1894. 82 pp + 53 ills. in text, with a summary in French witt this title. Du developpement de la colonne grecque.

M. Dieulafoy. L'art antique de la Perse. 1884-1886. Part III, sect. 4. (See particularly p. 52, an entire series of ivories from Nineveh and preserved in British Museum.

Puchstein. Das Ionische Capitell. 1888.

Nospiamotte. L'architectura Ionica etc. 1897. 41 pp+ 34 figs.

As for the column and the capital, reasons of sentiment a and of taste were obeyed by the architect; but it was not the

that composed of the bundle of erect leaves, which expands like a basket (Fig. 282, 283). That form likewise appears to be of foreign origin; but is no longer in Asia that its model is to be sought; it is in Egypt. There is a sensible analogy between this type and that presented by one variety of the Egyptian capital, the capital having as ornament a boquet of palms.[3] Particularly the architects of Saite princes appear to have brought this type into fashion; when the Greeks penetrated into Egypt, they found it nearly everywhere in the edifices of the cities of the Delta; they took it there and used in occasion to diversify their arrangements.[4]

Note 3.p.661. Histoire de l'Art. Vol. II, Figs.337,348,349.

Note 4.p.661. Yet is is necessary to state that the calathi form of capital is also found on one of the Phrygian tombs of the valley of the upper Sangarios (Histoire de l'Art. Vol. V, Figs. 77, 97); but the sepulchre on which it is found is one of those to which it is difficult to assign even an approximate date; thus one cannot affirm that this monument is earlier than the Greek monuments, that present examples of the same type.

Further, everywhere except in the Doric style, the forms of the principal members of the architecture are thus derived from prototypes, that must be sought outside Greece, and in the Ionic style it is not the plan of the edifice, so l long as this plan retained its primitive character, that recalls arrangements familiar to oriental art. The Ionic temple has neither the prodomos of the Homeric megaron, nor that beautiful enclosure of columns, that the architect conceived as an addition to make it the Doric temple. To judge of it even by the so recent monuments of the Acropolis of Athens, the Ionic temple at its origin was only a narrow cella, on which columns appeared only to support the ceiling, when supports were needed other than the walls, or to decorate some external facade of the edifice. One feels himself there nearer the Semitic temple, with its sanctuary of very restricted dimensions and the extension that can be made to it by dependances of all sorts, than to the severe verity of the Doric temple. The latter had no annex except the propyleum that g gave access to it. On the contrary, it seems that there were enclosures of vast size around the great Ionic temples of A

same for the general arrangement of the building. Not in the religious architecture of the Orient could the Ephesians and Samians find the model of the temples, that in the course of the 6 th century they consecrated to their Artemis and their Hera. One knows what idea we have been led to form of the p primitive Ionian temple from the later monuments, which have seemed to us to represent it faithfully; now as we conceive this type, it would be poorly adapted to furnish the plan of an edifice, that by its amplitude and dignity would have appeared worthy of the august goddesses. The Dorian temple fulfilled these considerations. With its spacious cella and the colonnade surrounding it, in all Greece it had given satisfaction to the requirements of the piety of the people; men had adopted everywhere this type as that best suited for the dwelling of the immortal gods, and thus the Greeks of Asia were led to inspire themselves by it, when they desired to prove their wealth and power by the splendor of their edifices. While retaining its forms that long acquaintance had r rendered familiar to the eyes of the Ionians, the temples of Ephesus and of Samos were great peripteral temples.

If from this moment Doric art had conquered this sort of primacy, it is not by the effect of a difference of age. The Ionic style is as ancient as the Doric style. The origins of the latter are lost in the mysterious depths of Mycenaean G Greece; those of the other are to be sought in the old civilizations of the Orient. The first attempts that the Greeks of Asia made to give themselves a national art must date back to an epoch, that cannot be less distant than that in which the Greeks of Europe created the Doric order on their part; but the latter earlier succeeded in working out its formula, in deriving from its principle an entire system of well connected rules; at the same time to develop it, nothing was borrowed from the practices of foreigners nor from those of a rival style in Greece itself. Indeed for that reason it is the eldest son of the architectural genius of Greece

In these conditions, if one of the two styles must act on the other, the active part cannot fail to belong to the Doric style. As by right of primogeniture, this caused to be felt by its rival the ascendant of its prestige, and by the examples that it afforded, allowed that to complete and enrich

enrich itself, to attain to effects that the style could have never reached, if reduced to its own resources. How this influence was exerted, we have indicated. Not only the general shape of the edifice has it modified by giving it a double pronaos and the portico; we have shown it intervening also in the details to supplement a certain insufficiency, to give more amplitude to certain members of the architecture. Thus it introduced the frieze in Ionic architecture, which was l lacking at its origin. We shall see in the course of this h history this predominance of the Doric style leading to a c curious result,How will come a time when men will seldom build in Greece other than Ionic temples; but even then with the appearance of defeat and disappearance, the type of the Doric temple will continue to live and to impose itself on architects, even in those edifices whose forms will not be its own. All these Ionic temples will be so in a way, only by name and custom. Most frequently will they merely reproduce the plan of the Doric temple with a fidelity almost servile.

In its native country, the Ionic style commenced early to suffer without resistance the influence of the Doric style; but at least it has remained the uncontested master of the ground. For the entire duration of the archaic peeiod, one finds for mention on that coast of Asia Minor, only a single Doric edifice of some importance, the temple of Assos. If not without some peculiarities, this temple represents the art of European Greece on the eastery shores of the Egean sea, it appears, that in this men long abstained from attempting to use the style, which had already made its mark by endowing with sumptuous edifices the most celebrated cities of Ionia. One cannot cite a single example of the Ionic order built before the middle of the 5 th century outside Asian Greece and its colonies; if after the end of the 6 th century Delphi saw aries on its sacred way a little building or treasury, on which the Ionic style displayed all its elegance, this is because the Cnidians that built it, desired to be r represented near the temple of Apollo by an edifice marked by the stamp of the art, which was alone practised in the country that they inhabited. At Olympia the citizens of Gela took a similar method, when it was necessary for them to dec-

decorate their treasury.

Until after the Median wars, this art was then only practised by a single fraction of the Greek race; one can almost call it a provincial artl if this word had a meaning in Greece, and if in the 7 th and 6 th centuries the Ionians had not been in advance of their brothers in Europe, and if they had not then formed the advance guard of Hellenism. It was due to the intelligent initiative of Athenian artists, that it should not remain confined to its hereditary domain, and should finally pass over the Egean sea about 450. Grealty fallen, yet still commercial and wealthy, Ionia was then comprised in the maritime empire of Athens, and was continually visited by its merchants and mariners, by its tax collectors and generals. Thus they were always going and coming from L Lesbos, Samos, Chios, Ephesus and Miletus to Piraeus.

Perhaps those skilful and learned architects had made the journey, Ictinos, Mnesicles, Callicrates, and yet others whose names escape us, that Cimon and Pericles charged to decorate the Acropolis by edifices in harmony with the position of Athens, become the real capital of Greece. Even in Ionia, in the temples of ancient and glorious cities, they had appreciated the graceful slenderness of the Ionic shaft and the beauty of its capital; they resolved to employ it for the d decoration of the field entrusted to them. Ionic forms had until then been employed at Athens only to crown steles, pedestals and statues, themselves most frequently the work of Ionian sculptors; the innovation was to apply them to the construction of edifices, that did not pretend to rival by their mass the majestic grandeur of Doric monuments like the Parthenon, but on which a finer art more lavish in ornaments could exhibit all its resources; there would be materials f for happy contrasts. Further, the Attic masters accepted no liability beyond the inheritance from their Ionian predecessors. When they trace the plans of their Ionic temples, if they had not taken care to use the freedom suited in that respect to the style, whose principle they had adopted, they left to their predecessors the modillions and dentils, a too literal transcript of the primitive structures of wood; they modified the composition of the entablature; without confusing that with the Doric entablature, the former had its div-

divisions, and thus lent itself to receive an additional ornamentation from the hand of the sculptor.

From that moment, Ionic art was transplanted and naturalized at Athens, and ceased to be the exclusive property of t the Greeks of Asia. By the light retouches received from the delicacy of Attic taste, it conquered in all Greece the right to citizenship; it became the second of the styles of Hellenic architecture. Henceforth the monuments of this style multiplied; one sees them arise at Delos, Delphi, Olympia, also in Sicily and Magna Grecia. Further, this was not the sole use that the architect made of this order; also sometimes to vary its effects, he placed the Doric and Ionic in the same e edifice. In such a case the forms borrowed from the Ionic s style played a secondary part; thus in a temple where the columns of the portico and of the pronaos are Doric, those of the interior can be Ionic.

The first example of this sort of hybridization appears to have been given by Mnesicles in the propyleum of the Acropolis in Athens; that example was followed by the architects that constructed the temple of Athena Alea at Tegea, the temple of Apollo Epicurios at Bassae, and much later the propyleums at Eleusis.

By adopting the Ionic order after revision and correction, Athens then conferred on it an importance and dignity, that it had never acquired before, and opened to it a new and more extended career. What Athens thus did for one of the arts of design recalls the influence that it exerted in the domain of letters. There also it gathered the heritage of those Greeks of Asia, that had commenced and essayed all. Ionia had seen arise philosophic and scientific speculation with Thales, Anaximenes and Anagoras; this assumed more rigor and a different scope at Athens with Socrates, Plato and Aristotle; the solutions attained by Grecian thought, and the hypotheses that it emitted are stated in the works that posterity collected and has not ceased to meditate. Historical investigations were inaugurated by those called the logographers, Hellonicos of Lesbos, Cadmos and Hecateus of Miletus, Xanthos of Sardes; but it is at Athens, under the impression of its warlike prowess, that it accomplished for the benefit of all Greece, that a Dorian of Halicarnassus, Herodotus, writes t

the first history worthy of the name. Soon an Athenian, Thucydides, will compose that history of the war in the Peloponnessus, which by the power of reflection and the depth of analysis, is one of the most admirable monuments of Grecian genius. It is the same for the epic and the lyric poetry, those two daughters of the imagination of the Eolians and Ionians; when they have exhausted their vein, they revive in the tragic drama at Athens. The scenes and dialogues of the tragedy replace on the stage in another form the myths and personages created by the epic poetry; its monodies and especially its choruses and odes, in which their pathetic and colored expression find all the feelings that move the soul of man and of the citizen. Thus converge toward Athens and guide us there, all the roads that we have followed in the study which we have undertaken. At Athens has all been arranged, matured and brought to perfection; there and by it was completed the prodigious and lengthy work of birth, of artistic and literary production, which for us commenced at Mycenae, Tiryns, Orchomenos, in Thessaly, to continue with infinite diversity of inventions and efforts in all Grecian colonies located on the coasts of the Mediterranean, and particularly in the brilliant cities of Asian Greece, in that Ionia, that has justly been called the springtime of Greece.

Additions and Corrections.

Page 65. W. Reichel is certainly one of the learned men b best acquainted with the Mycenaean world, and who has studied it with the most sagacity; better than anyone else, he has brought into light traits, which in the tales and scenes of the most ancient parts of the epic poems yet belong to t the civilization of the preceding age, and can serve to illustrate end define the idee given to us by the anepigraphic monuments of the primitive art. Thus one reads with a lively interest the new Memoir that the author of Homerische Waffen has recently published under this title; Ueber vorhellenische Götterculte. 1897. We received it only when our Book XII was printed; thus we cannot profit by all the acute observations and ingenious conjectures contained in it; but in spite of the regret felt for this, we believe that cannot accept all of his theory. We are inclined to think with him, that there did not exist at Mylenae and at Tiryns statues of the deity placed in a sanctuary, and we are greteful to him for having called attention to the cult of the throne, whose tradition was so long retained in Laconia in the cult of Apollo Amyclea, and whose trace also exists in the epithets euthronos, chrysothronos, that Homer so frequently applies to his gods; but it seems to us demonstrated, that the so called prehellenic societies had already attempted to translate by images the religious conceptions, that had formed what has been termed their polydemonism. We have found those images in the figurines of lead, bronze and clay, that have appeared to us to be idols; particularly in the engraved stones that have furnished us with numerous examples. Finally, the epic poetry seems to us to prove, that during the course of the two or three centuries that followed the fall of the Achaian kingdoms, among the tribes whose geniss created the immortal types of the Olympian gods, attempts were already made to give a body to those gods, that men represented to themselves as so noble and so beautiful. We grant indeed, that those attempts must be very timid and very awkward; but we cannot accept the interpretation, that Reichel gives of the verse where the poet relates that Theano, priestess of Athena, placed the peplos offered by the Trojan women "on the knees of the goddess." Reichel understands, "on the empty throne, at the

place where nould be found the knees of the goddess, if which was not the case, there had been a statue of Athena seated there." The explanation appears to us as singularly forced; it misunderstands the customs of that poetry, which ordinarily expresses so frankly the impressions received by the senses, and which depicts the chosen scenes by precise and colored epithets. Is it not simpler and more natural to assume there a xoanon, doubtless of very rude form, that all clothed in rich fabrics, like certain of our old madonnas, represented the goddess seated on her throne inliad with gold and ivory.

Here, as also sometimes in Homerische Waffen, the fault of Reichel, so learned and acute, is exaggeration. He too strongly desires to react against the opinions adopted before him; he is too systematic and too absolute. He carries to the extreme, doctrines, that if tempered by certain resources and certain distinctions, would be the truth itself, and would be imposed on criticism.

Pages 114, 115. concerning the dogs that the epic poetry substitutes for sphynxes or lions as guardians of the doorway, see what M. Pottier writes:- "I have always been surprised," he says, "by those dogs that guard the doorway, and I have asked myself if we do not have there the result of a bad interpretation, made by a Greek, of monuments of an Asian character, monuments that in reality represented lions of panthers; on the Corinthian vases themselves, those animals sometimes have the appearance of dogs. I will mention to you a more typical passage relating to the chyon. In the Odyssey (XIX, 228) is a mention of a dog, which uith his forepaws h holds a dying fawn. Here the improbability is still greater. a dog does not hold his prey between his paws; this is rather the attitude of a feline animal, and the image of a wild beast holding in his paws a slaughtered fawn naturally recalls the idea of numerous oriental works of art, the more that in the passage of Homer it concerns an embroidery of a mantle, and that one knows how much the Greeks admired and sought for fabrics woven on the loom or embroidered by the needles of Syrian women. Then I would see in these two passages an allusion to a work of oriental art, certain details of which had been badly comprehended by the Greek epic poet."

Page 149, Figs. 28-31. In regard to these dolls in the form of bells, M. Pottier stated to me, that they resemble the s sort of little idols, that one sees on the famous bezel of a golden Mycenaean ring (Histoire de l'Art. Vol. Vi, Fig. 425), on which they have the appearance of being suspended in space. It seems that there is a relation to be noted, like that of the great shield with notches, between the Mycenaean epoch and that of the Dipylon. It is probable that thhere was retained in the costumes of women the custom of employing pieces of cloth, which gave expanded petticoats in the form of bells, an arrangement that modelers in clay expressed even more naively in their figurines, than the engravers of intaglios had done in the preceding age.

Page 170. In reference to the bent cross or swastika, one will consult with benefit a recent work - Wilson, T. The swastika, etc. 1897. No theories are there. The author makes no effort to discover the signification of the symbol, the different meanings that it might assume among the different peoples that employed it. He desired to present particularly a collection of facts and figures; he especially emphasizes the presence of the swastika in the New World.

Page 206, Note 5. To the the works that we have cited in regard to a primitive geometrical style much earlier than t the pottery of the Dipylon, add a study by S. Wide. (Athen. Mitt. XXI, p. 385-409, Pls. XIII-XV). There is given an account of the discovery of a group of tombs in which were found vases with incised geometrical ornamentation, which belonged to the most ancient times of the Mycenaean period, and that represent a rural art contemporaneous with the royal art, f formed under foreign influences, to which is due what is termed Mycenaean ceramics. The author sees in that rural art t the ancestor of the rectilineal geometrical styce, whose wisest form is the style of the Dipylon. He rejects the idea that the Dorians contributed to introduce into Greece a new style, derived from the bronze civilization common to all t of central Europe. M. Wide does not share our idies on this subject; but one will no less appreciate the data, that he h has collected on this rudimentary ornamentation, that was c certainly used in Greece before the arrival of the Dorians.

Page 208-209. To our observations on the persistence with

which were retained certain Mycenaean motives in the art of a later age, one can add the remarks of S. Wide. Nachleben mykenischer Ornamente (Athen. Mitt. Vol. XXII, pa 233, Pl??).

Page 258, Note 1. We have given a very full analysis and appreciation of Reichel's book on Homeric Arms in the Jour. des Savants. (Dec. 1895, Jan. 1896).

Page 259. With regard to the mitre, see the Article of M. Perdrizet. Sur la Mitre Homerique. (Bull. Corr. Hell. 1897. p. 169-183, pl. X, XII). perdrizet understands the mitre as Reichel did, and he finds an example of it in an unpublished bronze of Delphi, that his plates represent as seen from front and side. The statuette is 7.55 ins. high; it represents a nude and beardless youth, who wears on his skin between t the chest and abdomen a sort of wide belt. The same indication is found on other figurines of the same kind, not so well preserved, that were collected at Delphi. The statuette would date from the beginning of the 6 th century. Already worn in the Mycenaean epoch, the mitre then remained in use long after the time of Homer.

Page 361. Insert in the title of Figs. 186, 187, instead of "and that of the naos," read "and that of the portico."

Page 486. Line 8. Instead of "temple", read "temple R."

Page 523. The machines employed for hoisting and setting blocks of large dimensions are mentioned in the accounts of the construction of the temple of Apollo Didymeus. One of t these appears to have been a shears. There is a mention in the same textof inclined planes, "on which have been raised the two statues, and the stones of the pedestal were transported." (Haussolier. Temple of Apollo Didymeus in Revue de Philologie. 1898. p. 47-48.

Page 550. one of the most recent studies on the subject of the proportions of Greek temples is the Essay of M. A. Marquand, entiteld: A Study in Greek architectoral Proportions. The Temple of Selinus. (Am. Jour. Archaeol. 1894. p. 521-528). Also see an Article by Dörpfeld. Die Proportionen und Fussmasse Griechischen Temple. (Arch. Zeit. 1881. p. 261-270).

Page 598. Among the monuments of the 6 th centsry that later rebuilding has caused to disappear, it is proper to mention the temple of Athena built of tufa, which was replaced in the 5 th century by the marble temple, whose columns are

still standing on cape Sunion. Its remains were found by Dörpfeld. (Athen. Mitt. 1884. p. 324-337. Pls. XV, XVI).

Page 604. Vitruvius (preface to Book VII) speaks of the Heraion of Samos as of a Doric monument. There is either a slip of the writer, or an error in an early copyist. There can be no doubt of the name to be given to the great Ionic edifice, whose ruins are yet to be uncovered, but whose perimeter has been measured, concerning the temple whose column we describe; it was certainly the temple of Hera, the glory of Samos. There have been found in the vicinty fragments of a building of the Doric order; but that seems to have been much less important; its order is at a much smaller scale. In the accounts of the temple of Apollo Didymeus the frieze is not designated by the ordinary name of zoophoros. It is there named by a word not yet found either in writers or in inscriptians, chosmophoros, "that bears the ornaments." This term is as well formed as zoophoros, and is better suited for most Ionic friezes, where the surface is not decorated by living figures, but only by foliage, flowers, palmatiums, etc. (Haussoullier in Revue de Philologie. 1898. p. 49.

Page 423. Fig. 215. Instead of "internal column of the temple of Demeter," read, "internal column of the Basilica."

And in line 37; instead of "in the temple of Demeter," read, "in the basilica."

ALPHABETICAL INDEX.

PLATES WITHOUT TEXT AND VIGNETTES.

I. Plates without text.

II. Plates in text.

Fig. Table of figures and plans inserted in the text. Page.

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THE END.

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